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JUN 10 1940

NEW YORK'S RADIO SKYLINE (See Contents Page)

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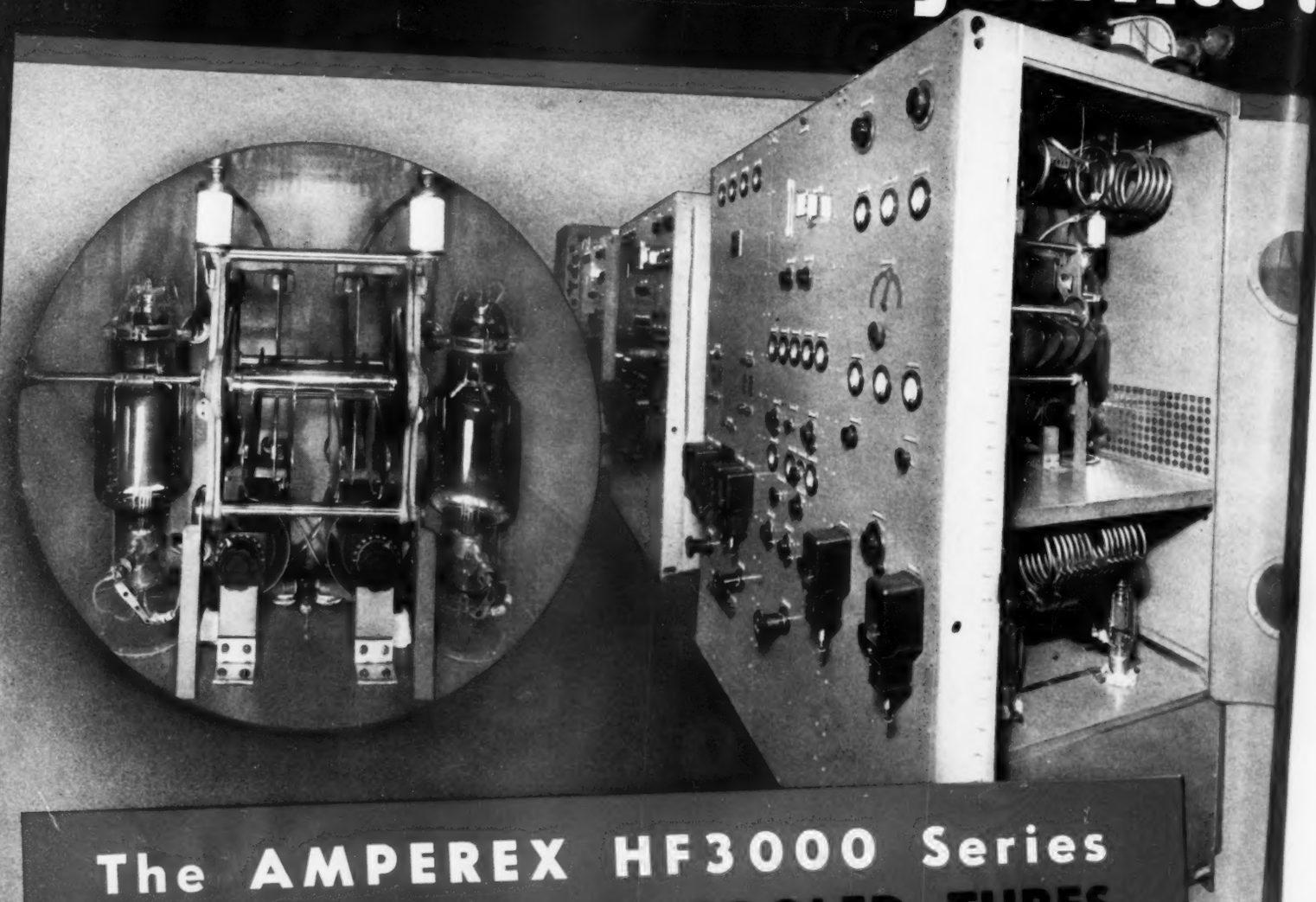

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Superimposed on the skyscrapers of New York is an oscillogram which covers the broadcast station spectrum of the city and reveals simultaneously the relative frequencies and signal strengths of the stations serving the metropolis. Taken on a "panoramic" receiver, described on page 14. The frequency scale reads from left to right (WMCA, WEAF, WOR, WJZ, WNYC, WABC, etc.), while the height of each peak indicates signal strength at 298 Broadway, New York

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CROSS TALK

▶**DEFENSE** . . . The invasion of the Low Countries of Europe will have at least two effects upon this country. One will be a complete awakening to the vital need for a tremendous expansion of our defense organization both moral and physical. Inadequate appreciation of the forces at work in Nazi Germany, in spite of adequate warnings available since 1927, is now having its terrifying effect. Belated appreciation in this country of those same forces will soon have its effect here and will be evidenced by an enlargement of funds spent for defense equipment.

All through the depression the government has kept busy many communication plants, large and small. This has been all to the good; and this work will continue.

There are, however, too many disquieting rumors of conflicts between the army and the navy, and between the services and the civilian expert aides. Jealousy between navy technicians and civilian radio experts, as only one example, creates havoc on morale, delays production, costs the people vast sums of money, time and effort. Politics enters into these vital matters all too often. All these matters should be delved into and cleaned up that we, too, happy in our ignorance and complacence may not be caught too late.

The second effect of the war will be an increased demand for war materials to be manufactured in this country. The Allies have some 7 billion dollars to spend; when this is gone there will be tremendous pressure to advance credit, all of which means busy factories and busy hands. But it will be a sad sort of activity, nevertheless.

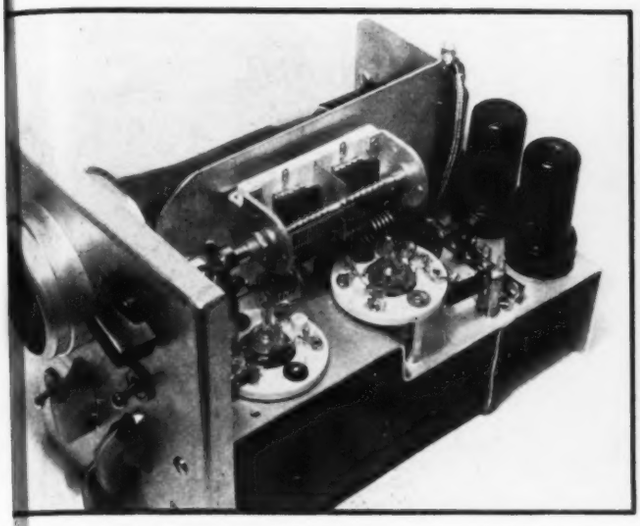
▶**WOLF** . . . Cyclotrons get bigger and better. The Rockefeller Foundation has made an appropriation of $1,150,000 to the University of California for a new cyclotron to be built under the direction of Dr. Ernest O. Lawrence. The University is to raise an additional quarter million dollars. The magnet will weigh approximately 4,500 tons, copper windings will weigh about 400 tons. At a wavelength of 57 meters, 50-million volt deuterons will be obtained. 2,500 kw will be available for operation of the machine.

Lately there have been new announcements of the energy available when, and if, certain nuclei are smashed—enough to run a big three-stacker liner across the Atlantic at 40 knots and all that sort of thing. We are getting a bit blasé about all these predictions. No one as yet has supplied atomic energy to push a dead fly across a frictionless surface. Atomic energy always seems to be one jump ahead of the scientists—they always need a bigger jimmy, and having got the jimmy the vision of releasing the energy is just as bright but is only delayed a bit in time.

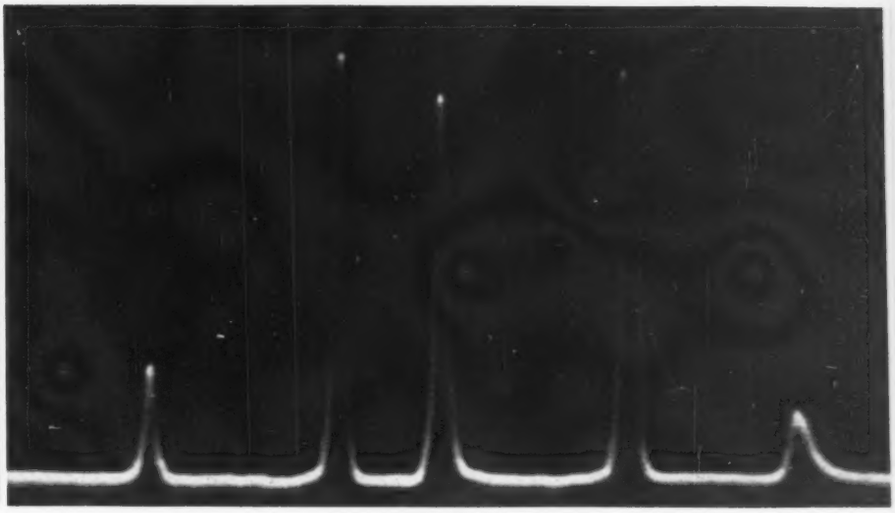
Knowledge about how things are made out of the ultimate building blocks of nature is sufficient excuse; scientists need not kid us along with these promises of something utilitarian. Can we Americans never enjoy beauty, or knowledge, or any of the esthetic qualities without wanting to know how much the thing cost, or what we are going to get out of it?

▶**MUSIC** . . . Among those receiving the 1940 medal awards presented by the Franklin Institute on May 15th, Laurens Hammond, President of the Hammond Instrument Co., will be the only person whose award will come as the result of an achievement that has had a far-reaching influence in the field of music. Mr. Hammond will receive the John Price Wetherill medal, an award founded in 1925 and bestowed annually to a person of outstanding achievement "for discovery or invention in the physical sciences, or for new and important combinations of principles already known". Mr. Hammond will receive the award "in consideration of the inventive skill displayed in the development of the Hammond Organ, a practical musical instrument for the production of tones of a wide range and pitch, intensity and quality by electrical means, and for the combination and manipulation of these tones with the speed, certainty and flexibility demanded in the production of musical compositions".

Mr. Hammond admits that he cannot read music or play it.



Development form of panoramic receiver built for extreme compactness and light weight. Uses electronic capacitance variation to sweep through the received band



Typical panoramic reception pattern showing transmitters on five frequencies, three of predominantly strong signal strength

change in the height of each V, may be identified if its frequency is related to the sweep frequency, as could readily be realized in the case of transmitters especially set up for beacon use. Noise appears as irregularities on the base line of the oscilloscope trace, and to some extent on the V itself, but the signals may be identified, as to relative frequency and amplitude, in the presence of noise which would make the signals almost inaudible if received by a loudspeaker.

This visual method of observing radio signals has several distinct advantages when applied to navigation. Navigation by radio is based by the comparison of signal strengths from two or more sources, usually on different frequencies. The panoramic receiver is essentially a signal strength indicating device for several signals at the same time, and hence the receiver is particularly well suited to the purpose.

The Dual Frequency Radio Range Beacon

One important application of the panoramic principle is illustrated in the range beacon recently demonstrated by Dr. Wallace at Indianapolis. The transmitter, shown in the accompanying photograph, consists of two line-controlled oscillators operating on 124 and 124.1 Mc respectively and feeding two horizontal dipole antennas arranged at right angles to each other. Since the radiation pattern of a single dipole is a figure-eight, the combined output consists of two figure-eight patterns superimposed. The transmitters were arranged for alternate keying by electronic keying circuits designed to operate in the range from 2 to 80 pulses per second.

The course to be followed by the plane is one of the intersections between two lobes of the double figure-eight pattern. It the pilot finds himself in this region, the two signals appear on the screen of his panoramic receiver as inverted V's of equal height. If he finds himself off course, in one of the lobes at either side of the intersection, the pattern on the screen shows him on which side he is off course, since the inverted V on the screen, corresponding to signal region in which the plane is situated, will be of greater height than the other. Moreover, the relative difference in the height of the two V's gives the pilot a direct indication of *how far* off course the plane is. As the pilot flies back toward the course, the two signal V's gradually assume equal amplitudes, whereupon the pilot knows he is on course. The system does not differ in principle markedly from the A-N radio range beacons now in use, since both depend on superimposed figure-eight patterns. But the panoramic system requires no manual tuning on the part of the pilot, is effective in the presence of a high degree of noise, shows the pilot on which side of the beam he happens to be, and gives a direct indication of the amount by which he is off course. The tests of this system showed that it is entirely practical as a range beacon service.

Receiver Design Factors

While the principle of operation of the panoramic receiver is simple, it must not be supposed that there are no controlling factors in the design. The tuned circuits, particularly those of the i-f amplifier, of the receiver operate under transient conditions when the oscillator frequency is swept over the band, hence care must be taken to allow full build-up of the resonant current in each circuit while the signal remains within the pass band of the i-f circuits. With ordinary i-f transformers having a Q of 50 to 100, it is necessary that about 20 cycles of the radio frequency current occur before the current reaches its maximum value. Furthermore, the signal applied to the i-f transformer is not constant while the signal passes over the pass band, but increases along one edge of the resonance curve and then decreases along the other. To take this factor into account, it has proved advisable to allow 40 cycles of the r-f current to occur while the signal remains within the pass band limits. Thus if the entire broadcast band from 550 to 1600 kc is covered in 1/120th second (one half-cycle of a 60 cps sweep), the intermediate frequency is 455 kc, and the bandpass is 10 kc the r-f input will oscillate about 40 cycles while the signal

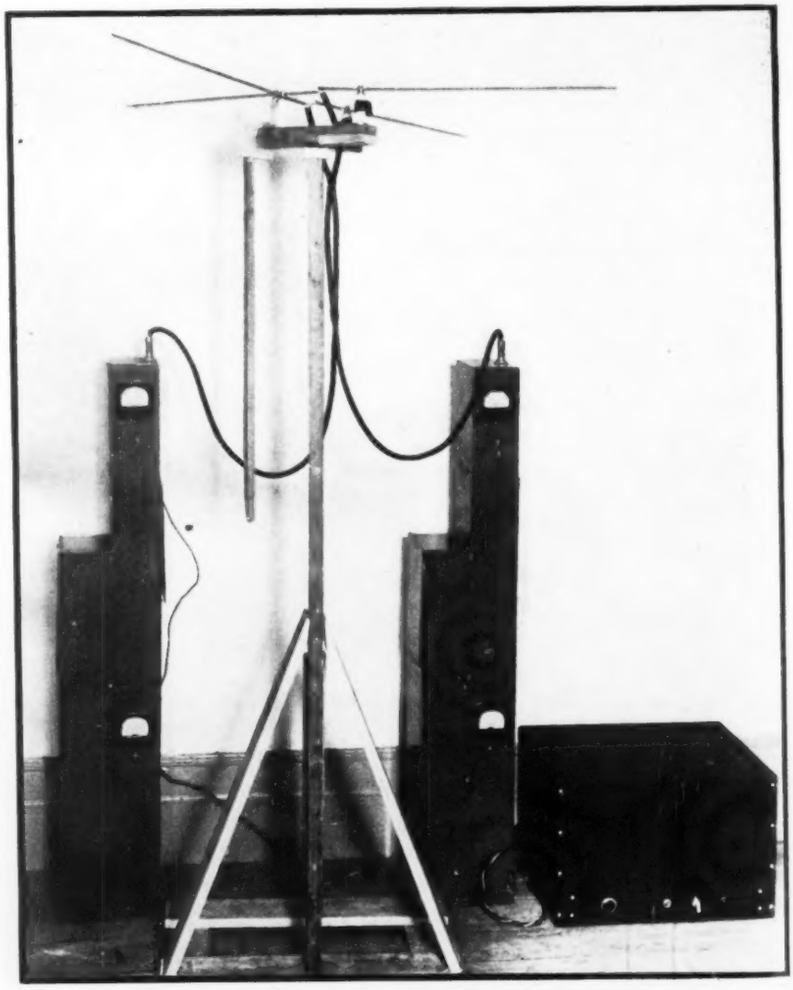
(*Continued on page 84*)

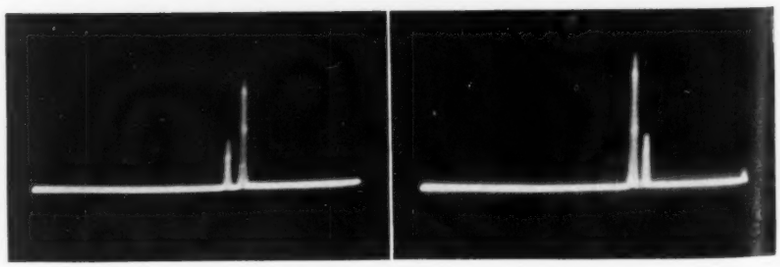
Panoramic Reception

All the stations on the dial of a receiver may be indicated simultaneously on a cathode-ray oscilloscope by repeatedly sweeping through the band. Such a receiver gives the relative frequencies and signal strengths of several stations, hence is suited to radio navigation

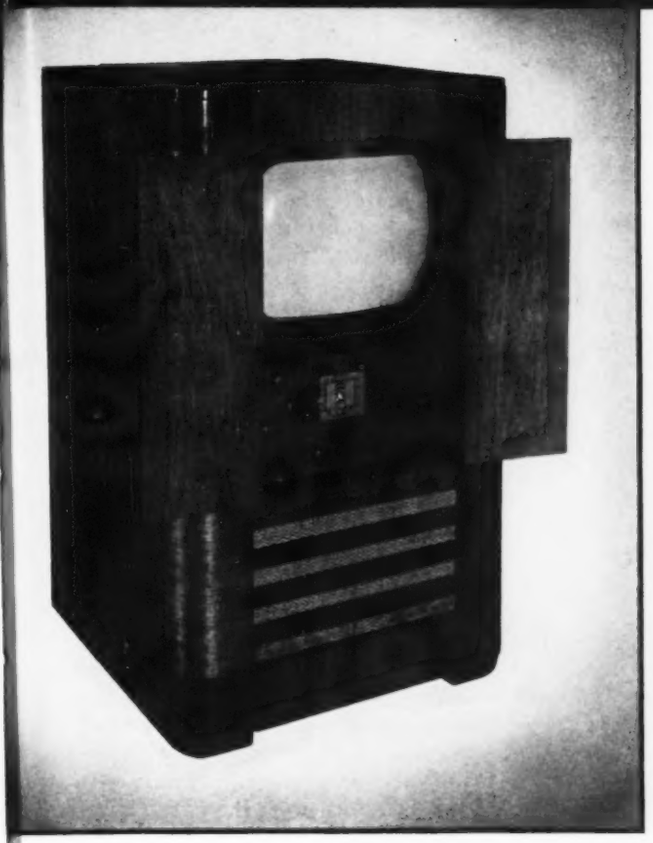
"PANORAMIC RECEPTION" is a name given to a newly-devised method of receiving many stations simultaneously, by its inventor Dr. Marcel Wallace of New York. The system is simple, so simple in fact that most engineers who have seen it demonstrated wonder why it has not been put into practice long before this. The first announcement published in *Electronics* was printed in July, 1938, page 36. Since that time more complete apparatus has been built and a demonstration of the system has been made to officials of the Civil Aeronautics Authority at the Indianapolis Airport, to show its effectiveness as a radio range beacon for aircraft.

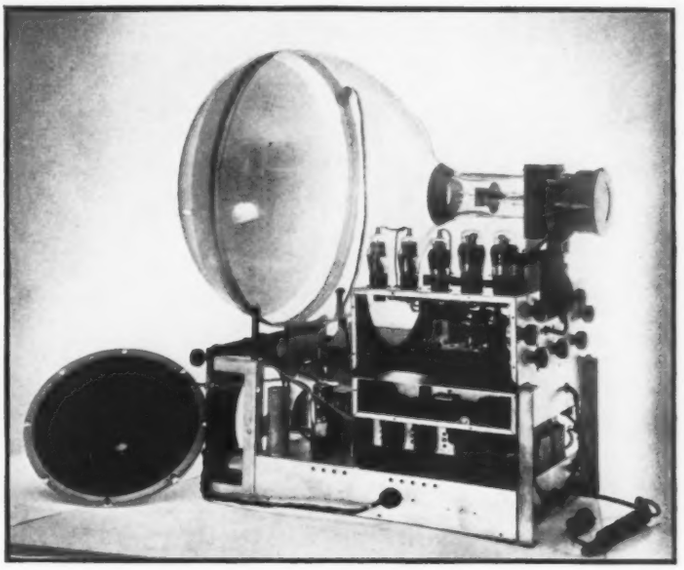
Essentially, panoramic reception is accomplished by observing radio signals on the screen of a cathode-ray oscilloscope. The receiver is a conventional superheterodyne in every respect except that the circuits of the oscillator and antenna are tuned continuously from one end of the band to the other at a rate of about 60 times per second. The receiver thus sweeps past the signals present on the band and registers an audio output voltage as each signal is encountered. The output is applied to the vertical deflection plates of an oscilloscope. The horizontal sweep frequency of the oscilloscope is controlled so that it is synchronous with the 60 per second tuning cycle. Hence each station on the band registers as a stationary vertical deflection of inverted-V shape. The height of the V is determined by the signal strength, its position on the horizontal axis by its frequency. Any change either in signal strength or frequency of any of the stations present, is immediately visible. Even the modulation of the signal, which produces a





The dual frequency aircraft beacon transmitter and panoramic reception patterns indicating off course to right and left of beam, respectively





Two views of the 20-inch receiver: left the console with broadcast and short-wave receiver; right, the chassis assembly proper which consists of five separate units

duces little acceleration or deceleration of the beam and tends toward a somewhat more uniform spot focus over the entire screen. Fortunately, however, the deflecting plates themselves by suitable balance of the positioning voltages may be utilized to correct the spot shape over the various sections of the screen and thus limit astigmatism of the spot below the disturbing value.

Both electromagnetic and electrostatic systems are fraught with difficulties regarding raster shape for wide angles of deflection. The term "raster" is frequently employed to describe the illuminated rectangle consisting of the scanning lines. Fringing effects of the magnetic deflecting coil are capable of producing a barrel effect of this rectangle. It is also possible to obtain a pin-cushion effect. Specific design of the deflecting yoke can offset these errors to yield a reasonably true rectangle. Electrostatic deflection may produce a trapezoidal effect on the pattern. The trapezoidal error is noticed most seriously when tubes are connected for so-called "single-ended" deflection and in which only one plate of each pair is used for signal, and the other plate of each pair is tied to the second anode. Fortunately, however, employment of both plates of each pair with signals of opposite phase and approximately equal amplitude from a push-pull deflection system corrects this trapezoidal error so that the electrostatic tube also produces a good rectangle.

It should be pointed out that the deflection sensitivity of a magnetic tube varies inversely with the square-root of the accelerating voltage while the deflection sensitivity of the electrostatic tube varies inversely as the first power of the deflection voltage. In this respect, for example, if one wished to double the accelerating voltage to increase brilliance he would require a larger change in the electrostatic deflecting system than in the electromagnetic deflecting system. However, at the present time very satisfactory deflecting systems have been developed for either type of tube operating at accelerating voltages from 6000 to 8000 volts.

Fourteen-Inch Tube

A tube chosen to provide a moderate sized picture has been used for some time in commercial receivers. This 14-inch tube operates at 8000 volts, utilizing the intensifier principle. An additional ring near the screen accelerates the pattern subsequent to deflection thus providing increased intensity without undue deflection voltage requirements. The bulb shape has been chosen so as to provide reasonable freedom from danger to implosion under the several tons of force subjected by the atmosphere on the evacuated bulb. The shape in the enlarged region resembles a sphere which is the strongest geometrical structure. This, of course, provides curvature to the screen, but a reasonable amount of flattening has been accomplished without sacrifice in safety. These bulbs are thoroughly tested both by a polariscope and by a pressure tank after careful annealing processes. The screen color is a nominal white screen, though a slight predominance of yellow seems to be most acceptable under average public viewing conditions. The phosphor consists of a mixture of materials. On analysis with a microscope when the tube is in operation one can see discreet particles emitting various colors but so closely spaced and uniformly distributed that the total visible effect is white.

The gun structure is illustrated in the accompanying photograph. A large neck is employed leaving adequate space for a high voltage seal through which nine electrodes are brought. The gun consists of an indirectly heated cathode surrounded by a control grid consisting of a

Television Receivers Using Electrostatic Deflection

By
THOMAS T. GOLDSMITH, Jr.
Director of Research
Allen B. DuMont Laboratories

IN this country, the DuMont Laboratories have been the leading exponent of the use of electric, rather than magnetic, forces for deflection in large television picture tubes. This article reviews the reasons for this preference and describes a typical receiver suitable for use either with a 14-inch or a 20-inch picture tube

THE television receiver design discussed here differs definitely from other receivers providing comparable picture size. Those features having primary engineering interest to both the designers and the users of television equipment are described.

The large picture tube is equipped with electrostatic deflection plates and is thus quite different from the large-sized tubes employed in other types of television receivers marketed in this country. Sets are available utilizing the 5-inch tubes operated electrostatically but for convenient viewing size and excellence of detail a number of manufacturers have chosen the electromagnetic system of beam deflection for the television scanning at the receiver, and considerable information has been published regarding the deflection circuits for these electromagnetic tubes. This article describes 14-inch and 20-inch cathode ray tubes utilizing electrostatic deflection plates. Such receivers present a different problem with respect to the sweep deflectors and the construction of the tubes themselves.

Electric vs Magnetic Scanning

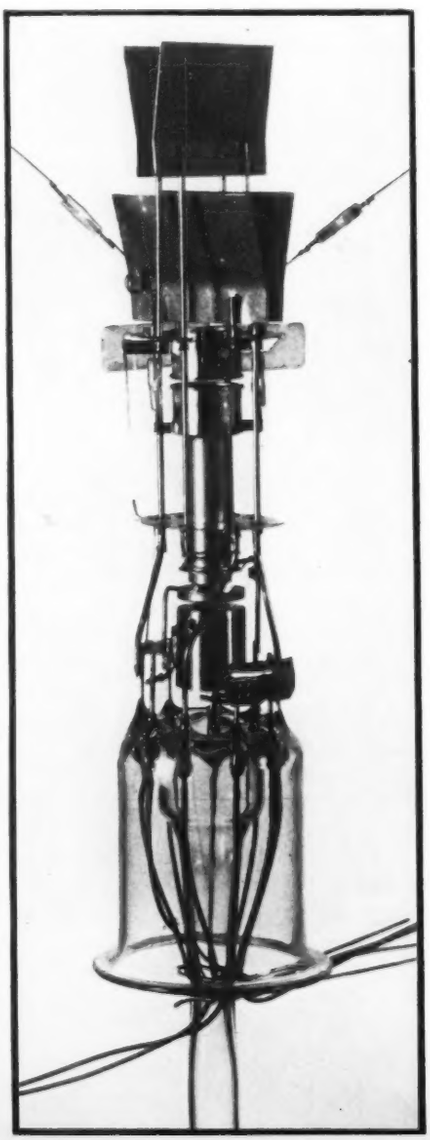
It will be well here to point out some of the current views with regard to the relative merits and demerits of cathode ray tubes operated with electric deflection as against magnetic deflection. Judged from a cost standpoint, the picture tube itself can be constructed somewhat more cheaply for magnetic deflection, since the alignment is not quite as critical, and the gun has fewer mechanical parts. However, this by no means constitutes a major item in the cost of the tube and, therefore, when a blank is once chosen suitable for the voltage insulation necessary, the expense of building the electrically deflected tube is very little more than the expense of building the magnetically deflected tube. The cost of a magnetic deflecting yoke is generally high and this item is not needed with the electrostatic tube.

Regarding the deflection circuits, it is a choice between providing high currents through suitable coupling transformers or high voltages through linear amplifiers.

In the case of magnetic deflection it is necessary to provide a peculiar waveform to provide the desired low frequency sawtooth current waveform, and furthermore, the requirements of rapid return time causes very high surge voltages in the transformer circuits so that insulation here becomes nearly as serious a problem with the electromagnetic circuits as with the electrostatic circuits. The deflection plates require only linear amplification of the originally-generated sawtooth voltage. Thus the cost of the amplifier components is probably about the same for either system, except for the deflecting coil.

An electrostatic deflection system has the great advantage of being able to follow wide variations in signal frequencies without the disturbance inherent with a magnetic deflecting coil. In other words, deflecting plates can operate with equal response over all frequencies from dc well up into the megacycles.

One particularly advantageous feature of electrostatic deflection is the freedom from screen burning due to the ion spot caused by negative ions. Such ions are deflected though with some loss of focus by means of electrostatic deflection plates. In this way the ions are scattered over a large screen area in the electrostatic tube and produce no disfiguring burned spot near the center of the screen. The matter of focusing of the beam warrants discussion. In general the magnetic deflection pro-



Gun structure and deflecting plates of the 20-inch picture tube. The deflecting plates are flared to obtain maximum deflection sensitivity and to avoid defocussing the spot

tube. A rubber block mounting structure holds the neck of the cathode-ray tube on this chassis. Most of the cabinet designs for these receivers utilize direct viewing of the screen, so that the cathode-ray tube lies horizontally.

With this five-unit assembly it is possible to test each of the five chassis individually, and furthermore the factory construction of the units is under more rigid control. The units may be transported more readily in this form which facilitates field work. Each assembly may be taken out by removing screws and detaching plugs.

With television still definitely in a development stage this unit assembly enables modifications to be made readily in the receiving circuits without obsoleting the remaining chassis which are not effected by the desired changes. For example, a change in a number of channels or, indeed, in the transmitted frequencies of television would require replacement of only a minor portion of the entire receiver. There are probabilities that one locality may require a different series of channels than another, and this construction still maintains standardized building and testing of the major part of the receiver.

Another feature of the unit design is its enclosed structure whereby each circuit is shielded adequately from other circuits likely to cause interference.

Production Test Procedure

The manufacture and testing of the cathode-ray tubes is an individual department in itself. These tubes are approved for alignment, brilliance, spot-size, deflection sensitivity and mechanical strength before assembly in the final receivers.

After assembly the power supply chassis are connected by their plug outlets to a standard load which at once indicates any flaw in the four rectifier circuits.

The r-f chassis is attached to a standard power supply and i-f unit. Standard signals are applied for proper alignment and band adjustment of the five channels. An r-f sweep oscillator is employed to observe the band response directly on an oscilloscope.

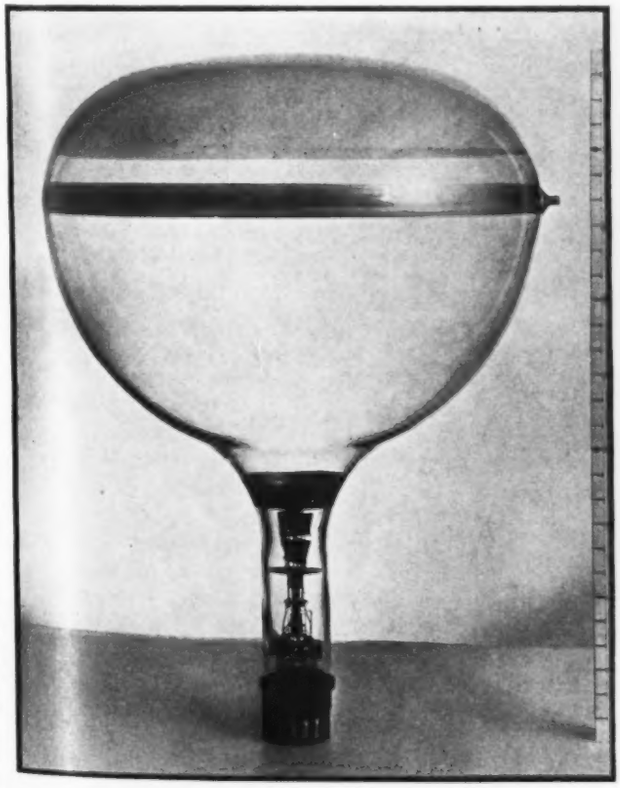
The picture intermediate-frequency chassis is adjusted with a sweep oscillator operating at the picture i-f frequency, and the signals are applied exclusively from the last intermediate frequency stage to the first. The output is observed from the detector on an oscillograph. The trap circuits are adjusted respectively to attenuate the adjacent channel picture signals and the adjacent channel sound carrier and the local channel sound carrier so as to avoid interfering signals on the cathode-ray-tube screen.

The sound channel is aligned at 8.25 megacycles with a standard signal generator, and its band width is sufficient to allow the slight frequency drift due to warming up and operation of the radio-frequency and local oscillator circuits. These transformers respond to a frequency width of 100 kc. The units are tested for operation of the a-v-c circuit and to see that the gain control and output stages operate free of distortion.

The top deck is attached to a standard assembly and a standard cathode-ray tube is inserted. Signals are applied to the input of the video amplifier. These signals consist of a standard pattern with the proper synchronizing and blanking pulses inserted. Such a pattern gives at once means for adjusting the frequencies, amplitudes, linearity and positioning of the two sweep circuits. With an oscillograph the sensitivity of the video amplifier is checked.

When each individual unit has

(Continued on page 89)



Typical image reproduced on a 14-inch tube using the receiver here described (441-line pattern)

The 20-inch electrostatically-deflected picture tube. Note accelerating electrode near fluorescent screen, which improves brilliance without affecting the deflection requirements

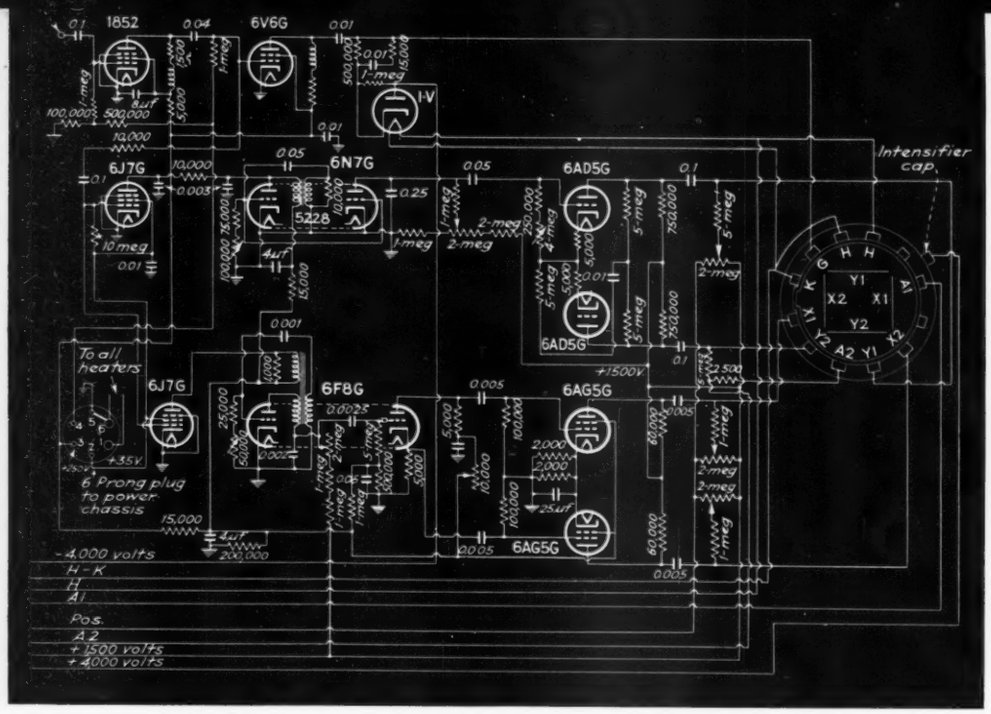


Diagram of the deflection chassis of the 20-inch receiver. The video signal from the second detector acts as input, and the output consists of synchronized vertical and horizontal sawtooth waves. In this chassis reside the main circuit differences between the DuMont receiver and those employing magnetic scanning

cylinder closed at one end except for a small hole through which the electron beam passes. Next is a preaccelerating electrode to provide a high initial velocity so that all electrons have essentially uniform energy before the focusing process is completed. This preaccelerator also has a defining aperture. A focusing cylinder of some length operates at the reduced potential and then the final high potential is applied on the second anode. The beam then proceeds through the two sets of deflection plates and is subsequently accelerated an additional amount by the intensifier ring before striking the screen.

Chassis Construction

The chassis design is based on a "five-unit" construction, as follows:

(1) Power unit. The entire bottom deck of the assembled receiver is devoted to the power supplies. This consists of a 300 volt supply to operate the receiving tubes in both the sound and picture channels. Another full-wave rectifier provides 1500 volts at low current to operate the final amplifiers for the sweep deflection. A third section is a half-wave rectifier supplying 4000 volts negative from ground to operate the electron gun. A fourth section has a half-wave rectifier supply 4000 volts positive from ground to operate the intensifier ring and this, of course, requires very little current, so the filter problem is simple. The transformer winding provides sources for voltage doubling to these last two rectifiers.

The entire power unit is protected by fuse and safety switches. The circuits are completely enclosed to remove the hazard of high voltage. Remote controls are used so that the high potentials and possible corona are limited to this enclosed region which greatly reduces the disturbances in the sensitive receiving circuits. The skeleton structure for insertion of the remaining chassis assemblies is built as a permanent part of this power chassis. Connection for power from the remaining decks is made by plug and socket for ease in assembling the units after individual test.

(2) R-f tuner. This small assembly contains the local oscillator and mixer tube with their associated r-f resonant circuit. Provision is made for five channels and with the structure chosen expansion of the chassis to include different or additional channels can be readily made without obsoleting the remaining assemblies.

(3) Picture intermediate-frequency chassis. This unit contains four stages of intermediate frequency amplification and a detector. The coupling transformers have associated with them suitable trap circuits to reject signals from adjacent television stations, and have an overall band pass of 4 megacycles. They are designed for intermediate frequency operation from 8.75 to 12.75 megacycles.

(4) Sound i-f and a-f chassis: This unit is fed by a link from the r-f unit and contains two stages of intermediate frequency amplication at 8.25 megacycles. A detector and a-v-c tube then feeds an inverter and a pair of 6V6 tubes in push-pull to operate the speaker. Phonographic attachment facilities are provided.

(5) Cathode-ray control assembly. This so-called "penthouse" structure contains the final stages of the video amplifier, the coupling circuits and d-c reinsertion circuit to the grid of the cathode-ray tube. It also contains the synchronizing separator tubes which pick off the peaks of the video signals and through suitable frequency discriminating networks apply them to the sweep oscillator tubes. These oscillator tubes provide a linear low amplitude sawtooth wave which is then inverted and amplified through balanced stages to obtain the necessary high deflecting voltages to scan the cathode-ray tube screen. A type of blocking oscillator is used to trigger off the sweep circuit. The amplifier requirements demand tubes capable of operating with the 1500 volt plate supply necessary to give the high voltage for the deflection plates. However, the current required in these amplifiers is low, and therefore standard receiving tubes may be used as far as thermal dissipation is concerned. However, particular requirements must be met with regard to voltage insulation of the inside elements and in the pins and wiring to the sockets.

The sweep chassis has certain controls mounted at the back, which adjust pattern size and line and frame frequencies. Positioning controls are supplied for centering the pattern, and an astigmatic control is provided which serves to correct spot shape distortion. This control varies the average d-c voltage about which one set of plates operates with respect to the average voltage about which the other set of deflection plates operates.

Since only this chassis utilizes the high voltage it has a special cable thoroughly insulated for the accelerating voltages of the cathode-ray

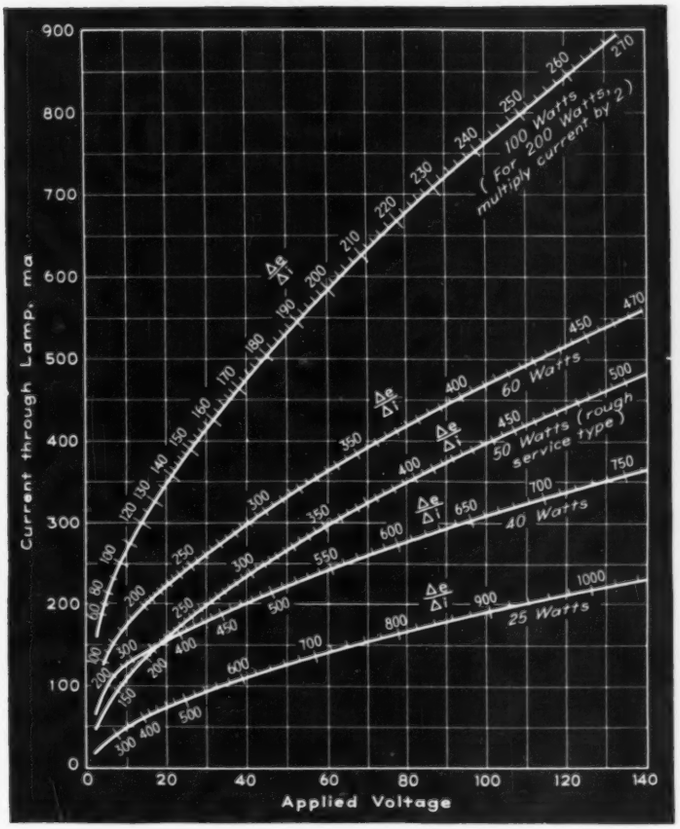
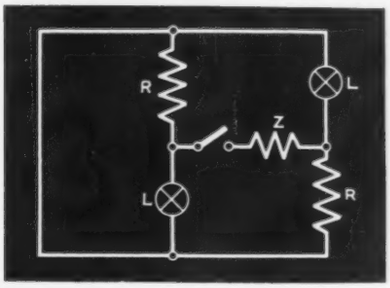


Fig. 3—Characteristic curves of commercial Mazda lamps. The dynamic resistance of the lamps is given by the scales on the curves

Fig. 4—Circuit used to determine the effect of a load impedance across the output terminals (Thevenin's theorem)



represents the current i_o. Now let the applied voltage increase by the amount ΔE to the new value OS'. The resistor characteristic shifts parallel to itself into the position $S'P'$; the voltage across the lamp will be OQ', across the resistor $S'Q'$, while the current will be $Q'P'$. Inspection of the figure confirms the initial reasoning, based on the resistance increase of the filament, that the voltage OQ' across the lamp is now higher than the voltage $S'Q'$ across the resistor.

If ΔE_L is the voltage increase across the lamp, and ΔE_R the voltage increase across the resistor, then evidently

$$\Delta E = \Delta E_L + \Delta E_R$$

while the difference of these two increases is the output voltage e

$$e = \Delta E_L - \Delta E_R$$

Referring to Fig. 2 it is seen that $\Delta E_L = QQ' = PV$ and $\Delta E = SS' = PT$; therefore $\Delta E_R = \Delta E - \Delta E_L = VT$. The increase in current Δi equals $P'Q' - PQ = P'V$. We now wish to express ΔE_L and ΔE_R in terms of the lamp characteristic, the resistance R and the increase Δi of the current. The increase $\Delta E_R = VT$ is simply the resistance R times the current change, that is

$$\Delta E_R = \Delta i \times R$$

If we consider the change ΔE small enough so that the part PP' of the actual lamp characteristic can be replaced by the tangent without appreciable error, we can write

$$P'V = PV \times \frac{di}{dE}$$

or

$$\Delta i = \Delta E_L \times \frac{di}{dE}$$

and

$$\Delta E_L = \Delta i \times \frac{dE}{di}$$

dE/di has the dimension of a resistance. The plate resistance of a radio tube is defined in a similar way. We may call dE/di the dynamic resistance R_D of the lamp at the operating point P. With this we can write

$$\Delta E_L = \Delta i \times R_D$$

Substituting these expressions into the equations for ΔE and e, and solving for e

$$\Delta E = \Delta i\,(R_D + R)$$

$$e = \Delta i\,(R_D - R)$$

and

$$e = \Delta E\left(\frac{R_D - R}{R_D + R}\right)$$

Figure 3 shows the volt-ampere characteristics of the common size 115 volt Mazda lamps. Along each curve are given the values of R_D.

Example: Using 60 watt bulbs, determine the resistor for a bridge balance at $E_o = 110$ volts and give the unbalance voltage e for a 2 volt variation in the voltage applied to the bridge.

Solution

$$R = \frac{E_o/2}{i_f} = 55/.347 = 158 \text{ ohms}$$

R_D at 55 volts from curve: 325 ohms

$$e = 2 \times \frac{325 - 158}{325 + 158} = .69 \text{ volts.}$$

The unbalance voltage e is usually not enough to operate a gaseous tube. There are several ways to raise this voltage. In the first place a transformer may be introduced between the voltage to be regulated and the bridge itself, so that the lamps are operating at a voltage nearer to their rated voltage. This steps up ΔE in the transformation ratio. It has the added advantage that the lamps, which are operating at a higher temperature, respond to the voltage variations faster with corresponding resistance changes than when operating at lower temperatures. However, even with this a step up transformer is usually required between the points C and D and the tube, serving at the same time as insulating transformer. This transformer constitutes a load between the points C and D, and will decrease the calculated open circuit output voltage. Fortunately there is no difficulty in accurately predicting its influence, or that of any other load impedance Z connected between the points C and D. This is easily accomplished by the application of Thevenin's theorem, accord-

(*Continued on page* 108)

Voltage Control With a Non-Linear Wheatstone Bridge

By WALTHER RICHTER
Consulting Engineer, Milwaukee

A voltage control device which combines simplicity with utility is that consisting of a Wheatstone bridge which has two linear and two non-linear elements in opposite branches. The incandescent lamp is probably the simplest and most widely available non-linear resistance element and therefore forms the basis of the circuit described here. A typical non-linear Wheatstone bridge circuit is shown in Fig. 1.

The non-linear relation between voltage and current of an incandescent lamp is due to the fact that an increase of voltage across the filament and the consequent increased current through it, raises the temperature and therefore the resistance, of the filament. Assuming identical lamps and resistors in the two branches *ACB* and *ADB* of the bridge, it is clear that the bridge is in balance, that is the voltage e is zero, when the lamp resistance R_L equals the resistance R. If E_o is the voltage applied to the bridge for a balanced condition, and i_o is the current in each branch, the voltage across each of the four arms of the bridge is then $E_o/2$. If the applied voltage rises above the value E_o, the currents in the two branches *ACB* and *ADB* each rise by an equal amount. This increases the voltages across *AC* and *AD*, but since the lamp resistance R_L is increased due to the temperature rise of the filament, the voltage *AC* will rise more than the voltage *AD*, and the point *C* will show a positive voltage with respect to point *D*, equal to the difference between the voltages across the lamp and the resistor. If the voltage E is decreased below the value E_o, at which the bridge is in balance, similar reasoning shows that *C* becomes negative with respect to *D*. For an applied alternating voltage this means that the voltage between *C* and *D* is in phase with the voltage between *A* and *B* for $E > E_o$, is zero for $E = E_o$ and is 180° out of phase for $E < E_o$. Obviously, this is a tailor-made condition for the control of thyratrons and other gaseous tubes. By combining the voltage e with a fixed alternating voltage 90° out of phase, a voltage suitable for the well known phase shift method of tube control can also be obtained over a reasonable range. The purpose of this discussion is to show how the designer of such circuits can calculate the output voltage e for a given variation of the applied voltage E. This permits him to predict the performance of a given arrangement, or if definite limits are set for the variation of E, he is able to specify the step-up equipment—either transformers or amplifiers—needed between the points *C* and *D* and the grid of the final tube.

With the foregoing explanations in mind it is obviously an easy matter to determine the value of the resistance R necessary to produce balance at a given applied voltage E_o. Suppose that the bridge is to be in balance for an applied voltage of 120 volts, i.e. $E_o = 120$. We have seen that the voltages across all four arms must be equal at balance, which means that there must be $E_o/2 = 60$ volts across the lamp as well as across the resistor. From the volt-ampere characteristic of the lamp in question we find the current i_o of the lamp at an applied voltage of $E_o/2$; the resistance of the lamp is then $R_{Lo} = \frac{E_0}{2i_o}$ and this is also the value which the fixed resistor must have to produce balance at $E = E_o$. If 40 watt lamps are to be used as an example, we would find from the curves on Fig. 3 that the current taken by such a lamp with an applied voltage of 60 volts is 240 ma or 0.24 amp. The necessary resistance R is therefore 60/.24 = 250 ohms.

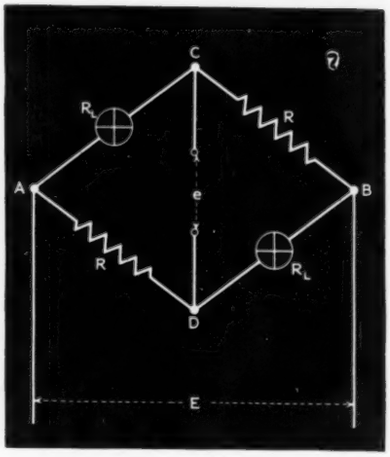


Fig. 1—Circuit diagram of a typical non-linear Wheatstone Bridge. The symbol R_L indicates the non-linear resistance elements and e represents the output voltage of the device

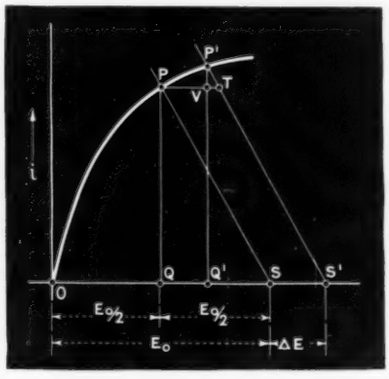


Fig. 2—Voltage-current characteristics of the linear and non-linear elements of the Wheatstone Bridge

It must be able to dissipate 60x.24 = 14.4 watts.

However, this does not answer the question how much control voltage (e) is available, if E_o changes by an amount ΔE. The problem can be solved in a simple manner. In Fig. 2 *OP* represents the lamp characteristic, and *SP* represents the volt-ampere characteristic of R, plotted from right to left, with *S* as the zero point. With E_o applied to the combination and R of the value as calculated in the previous paragraph, the voltage *OQ* across the lamp will equal the voltage *SQ* across the resistor, both being $E_o/2$, while *QP*

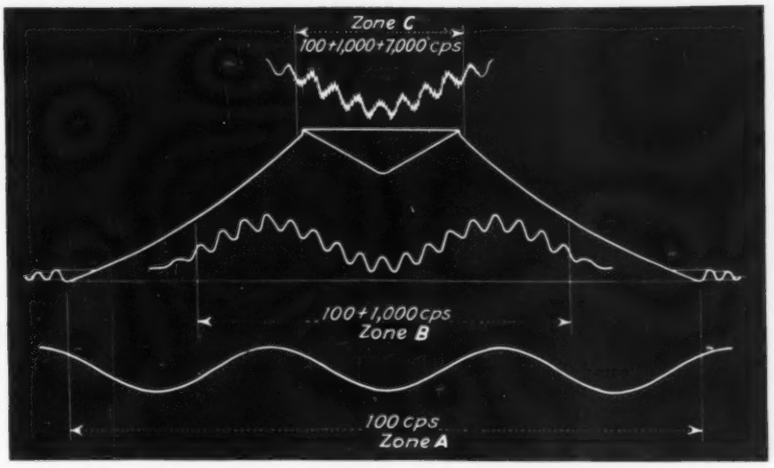


Fig. 3—Division of three frequency ranges along the structure of the polyfibrous cone

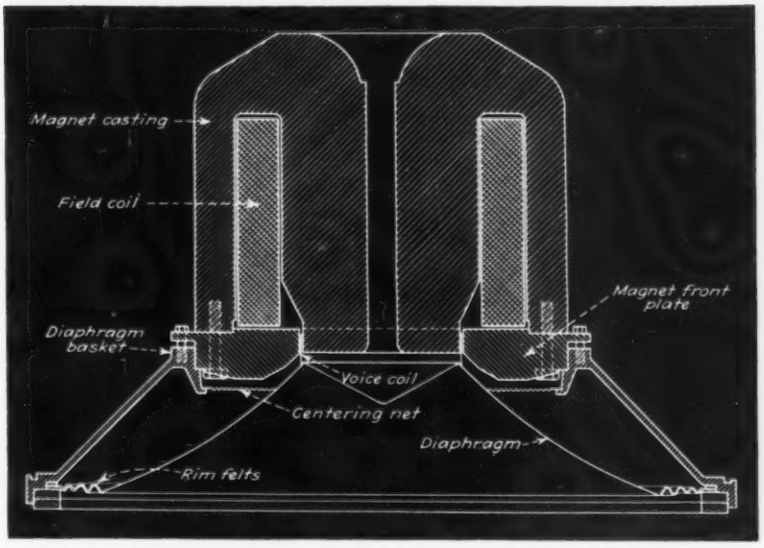


Fig. 4—Cross-sectional scale view of the cone and magnet structure. The magnet weighs 450 pounds, including the coil

voice-coil excursions, work was carried on from several angles.

The voice coil is wound with aluminum ribbon to provide less weight than copper for equivalent current carrying capacity. The ribbon form permits better utilization of winding space with a reduction in the number of turns required and a smaller gap with resulting increased flux densities for a given weight of magnet metal.

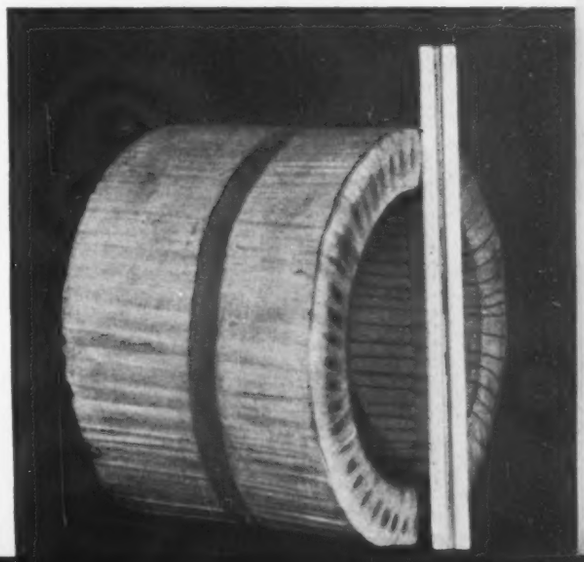
The next step was to provide the means for coupling this coil to the diaphragm; a means which must provide light weight, great rigidity (to transmit minute forces with the minimum of loss through compliance), freedom from warping, imperviousness to heat and moisture. Fortunately, development work in the laboratory had just been completed on a voice-coil form of a metal named "Acim". This material is highly tempered and provides a higher ratio of stiffness and tensile strength to weight than any form material encountered. As a result of this development it was possible to reduce the voice-coil form to paper thinness and still retain more than adequate rigidity and strength to withstand the high shock loads imposed on the moving system. This also meant further reduction in gap width, together with increased heat dissipation and consequently improved power-handling ability for the voice coil.

Turning to the cone, there are obviously other considerations involved than solely that of least possible mass. The weight of a 27-inch cone produces an inertia value in excess of the stiffness factors of any known types of paper. As a result, in experimental tests employing standard papers there was found the usual tendency for the cone to break up into various nodes of active and inactive areas which shifted continually with frequency. In addition the high-frequency waves evidenced a natural tendency to travel over the cone surface and be reflected back by the rim. One result of this was to prolong transient impulses; another was to produce non-linear response due to the varying phase relationships between exciting and reflected waves.

Reference to Fig. 2, Curve 3, shows the response characteristic of a speaker using a cone of standard paper. Curve 2 of this same figure shows the improvement accomplished through substitution of a special polyfibrous cone material used in the 27-inch unit. This has the effect not only of extending the frequency response range but of improving linearity.

The structure of this special material is such that its compliance varies gradually from extreme stiffness at the apex to considerable suppleness at the rim. The stiff apex area reproduces all impressed frequencies, as indicated in Zone C, Fig. 3, which illustrates in simple form the condition resulting when frequencies of 7000, 1000 and 100 cps are impressed simultaneously on this type of cone. The more compliant surrounding structure serves to absorb the 7000-cycle frequency, substantially confining its reproduction to a definitely prescribed area just adequate to provide the small re-

Fig. 5—The field coil, shown in comparison with a 12-inch engineer's rule. Flux density, 21,000 lines per sq cm



DESIGN of a 27-inch LOUDSPEAKER

For the Lagoon of Nations Display at the N. Y. World's Fair, 2000 watts of audio power are handled by a group of dynamic loudspeakers of extremely large size and high power-handling capacity. Details of the design, including provision for ¾-inch voice-coil travel, are here described

By R. T. BOZAK
Chief Engineer
United Teletone Corp.—Cinaudagraph

ONE of the problems associated with the Lagoon of Nations displayed at the New York World's Fair was to estimate the noise level resulting from location of the loudspeaker system in the center of the great fountain display. The sound had not only to penetrate the curtain of water, but to ride sufficiently above the noise to provide coverage of crowds of 100,000 or more spreading in a great oval with its inner edge an average of some 200 feet from the loudspeaker location.

The solution of this problem was found in the installation of very large 27-inch dynamic loudspeakers developed especially for the job. These units, so far as is known, represent one of the most ambitious undertakings in loudspeaker development to date. The large size was dictated by the desire to use a small number of individual units. Where large volume of sound is to be handled there are distinct advantages in utilizing the smallest possible number of reproducer units. If the angle of coverage is such that it can be handled by a single high-power speaker rather than a cluster of smaller ones, definite reductions in both phase and amplitude distortion are often possible. Large cone area is obtained in either case but a single large cone handling the entire power has greater travel-amplitude and the resulting higher velocity provides improved propulsion on low-frequency transients.

In the loudspeaker under discussion, for instance, the voice coil moves over a range of three-quarters of an inch under full low-frequency load. The result of this piston action on the air is to impart to the listeners a combination of feeling and sound the same as do a beaten bass-drum or the rumbling notes of the great organ, providing a highly impressive sense of realism.

A question naturally arises as to whether a large moving structure of such great mass and capable of such swing amplitude can at the other extreme follow the extremely rapid reversals and minute movements involved in the reproduction of a 10,000 cycle tone. The answer is perhaps best provided by the sound pressure characteristic of this speaker as shown in Fig. 1.

Such wide and flat response is not obtained without special measures involving materials and design, both electrical and mechanical. Mass must be held to a minimum if the flux requirements are to be kept within practical limits because it is only by maintaining a high ratio of magnetomotive force (in the voice coil) to mass that effective operation is obtainable.

The Voice Coil

In order to reduce mass to a practical minimum, at the same time producing a moving structure capable of withstanding the strain (proportionately far greater than in smaller speakers) to which it is subjected by the high power and wide

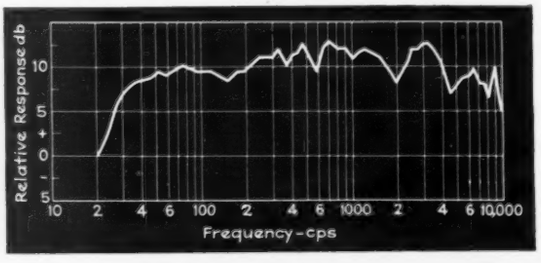
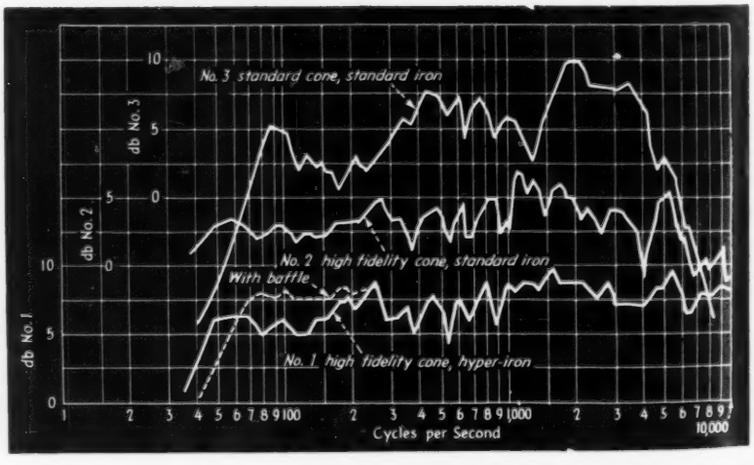


Fig. 1—Overall frequency response characteristic of the final form of the speaker, including baffle

Fig. 2 — Effect of different cone materials and magnet structures on frequency response curves. The final speaker employed hyper-iron and the high-fidelity cone



Institute of Radio Engineers
Fifteenth Annual Convention

June 27, 28, and 29, 1940, Hotel Statler, Boston, Massachusetts

Program of Technical Papers

THURSDAY, JUNE 27

10:00 A. M.—12:00 NOON, BALLROOM

"Marine Radiotelephone Design" by H. B. Martin, Radiomarine Corp.

"50-Kilowatt Air-Cooled Broadcast Transmitter" by R. N. Harmon, Westinghouse.

"RCA-NBC Orthacoustic Recording" by R. A. Lynn and B. F. Fredendall, National Broadcasting Company.

"Instrument Production" by E. H. Locke, General Radio Co.

8:00 P. M.—9:30 P. M. ROOM 10-250, M.I.T.

Popular Lecture "Microwaves—Present and Future" by Massachusetts Institute of Technology Group.

FRIDAY, JUNE 28

10:00 A. M.—12:30 P. M., BALLROOM

"Ultra-Short-Wave Transmission over a Fixed Optical Path" by C. R. Englund, A. B. Crawford, and W. W. Mumford, Bell Labs.

"Centimeter-Wave Detector Measurements and Performance" by E. G. Linder and R. A. Braden, R.C.A.

"The Inductive-Output Tube-Characteristics and Performance" by Bernard Salzberg, R.C.A.

"A New Ultra-High-Frequency Tetrode and its Use" by A. K. Wing, Jr., and J. E. Young, R.C.A.

"Available High-Mutual-Conductance Tubes" by E. W. Schafer and E. R. Jervis, National Union.

"An Ultra-High-Frequency Dosemeter-Diatherm" by J. D. Kraus and R. W. Teed, University of Michigan.

"Sparking of Oxide-Coated Cathodes in Mercury-Vapor-Filled Tubes" by J. W. McNall, Westinghouse.

10:00 A. M.—12:30 P. M., GEORGIAN ROOM

"Recent Advances in the Design of Cathode-Ray Oscillographs" by P. S. Christaldi, DuMont Labs.

"Oscilloscope Patterns of Damped Vibrations of Quartz Plates" by H. A. Brown, University of Illinois.

"A Method of Measuring the Magnetic Properties of Small Samples of Transformer Laminations" by H. W. Lamson, General Radio Co.

"A Radio-Frequency Bridge for Measurements up to 30 Megacycles" by D. B. Sinclair, General Radio Co.

"Coil Reactance in the 100-Megacycle Region" by Ferdinand Hamburger, Jr. and C. F. Miller, Johns Hopkins University.

"A New Electron Microscope" by L. Marton, M. C. Banca, and J. F. Bender, R.C.A.

"Stable Power Supplies for the Electron Microscope" by A. W. Vance, R.C.A.

2:00 P. M.—5:00 P. M., BALLROOM

"Aircraft Antennas" by G. L. Haller, Wright Field.

"Rain and Snow Static" by H. K. Morgan, T.W.A.

"Ultra-High Frequencies in Air-Transport Communication" by J. G. Flynn, Jr., American Airlines.

"Microwave Beams for Instrument Landing of Airplanes" by W. L. Barrow, M.I.T.

"A Microwave Receiver for Instrument Landing" by F. D. Lewis, M.I.T.

"Panoramic Reception" by Marcel Wallace.

"Radio Navigation and the Omnidirectional Radio Range" by D. G. C. Luck, R.C.A.

2:00 P. M.—4:00 P. M., GEORGIAN ROOM

"Optimum Conditions for the Operation of a Class C Amplifier" by E. L. Chaffee, Harvard.

"Power-Tube Performance as Influenced by Harmonic Voltage" by R. I. Sarbacher, Harvard.

"High-Efficiency Frequency Doublers" by J. E. Shepherd, Harvard.

"Space-Charge Relations in Triodes and the Characteristic Surface of Large Vacuum Tubes" by E. L. Chaffee, Harvard.

"Equivalent Electrostatic Circuits for Vacuum Tubes" by W. G. Dow, University of Michigan.

"Water and Forced-Air Cooling of Vacuum Tubes with External Anodes" by I. E. Mouromtseff, Westinghouse.

"Large Air-Cooled Tubes in 50-Kilowatt Transmitters" by I. E. Mouromtseff and W. G. Morgan, Westinghouse.

4:00 P. M.—5:30 P. M., GEORGIAN ROOM

Informal discussion on "Power Tube Operating Characteristics and Ratings" led by E. L. Chaffee.

SATURDAY, JUNE 29

10:00 A. M.—12:30 P. M., BALLROOM

"A Portable Television Transmitter" by C. D. Kentner, R.C.A.

"Small Iconoscopes of Recent Design" by W. H. Hickok, R.C.A.

"A New Method of Synchronization for Television Systems" by T. T. Goldsmith, R. L. Campbell, and S. W. Stanton, DuMont Labs.

"Synchronizing and Deflection Circuits of a Television Receiver" by R. E. Moe, G.E.

"A Type of Light Valve for Television Reproduction" by J. S. Donal, Jr., and D. B. Langmuir, R.C.A.

"Television Radio Relaying" by F. H. Kroger, Bertram Trevor, and J. E. Smith, R.C.A.

"The Influence of Filter Shape-Factor on Single-Sideband Distortion" by J. C. Wilson and H. A. Wheeler, Hazeltine.

1:45 P. M.—4:30 P. M., BALLROOM

"Interference Between Stations in Frequency-Phase Modulation Systems" by Dale Pollack.

"Interference Between Two Frequency-Modulated Signals" by Stanford Goldman, G.E.

"A New Broadcast Transmitter Circuit Design for Frequency Modulation" by J. F. Morrison, Bell Labs.

"Frequency-Modulation Systems Characteristics" by M. L. Levy, Stromberg-Carlson.

"National Broadcasting Company's Field Test of Frequency Modulation" by R. F. Guy and R. M. Morris.

"Demonstration of Frequency-Modulated Wave Broadcasting Systems" by E. H. Armstrong and P. A. deMars.

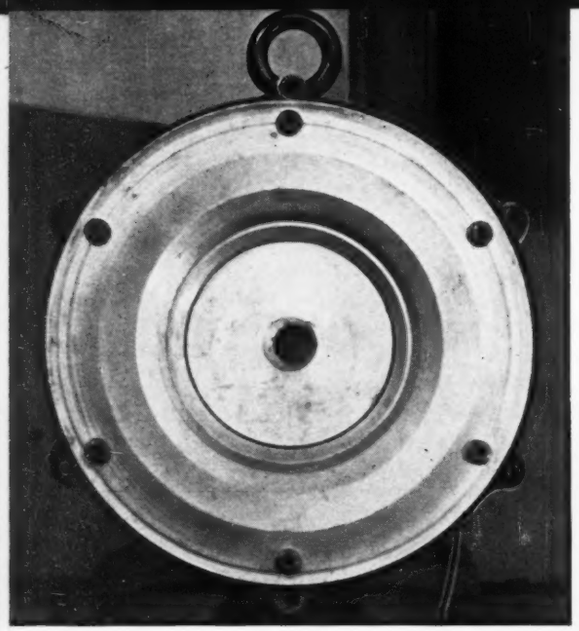
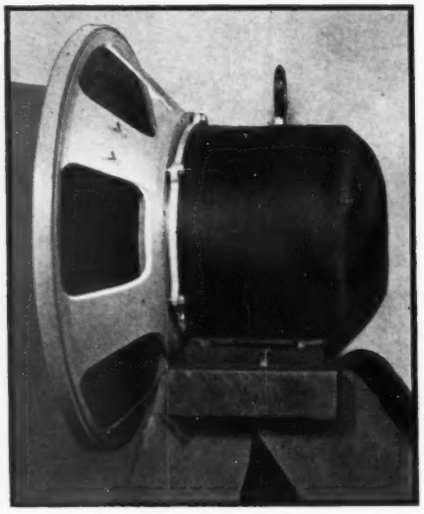


Fig. 6—Assembled magnet structure showing gap for voice coil. By the use of a very thin metal form for the voice coil and small gap clearance, high flux density is achieved

Fig. 7—The speaker completely assembled. Excepting size, the main physical difference compared with smaller speakers is the large size of the magnet pot relative to the cone housing



quired coupling to the air. This absorption prevents the waves from reaching the rim and thus avoids reflection. In Zone B both the 1000 and 100-cycle tones are reproduced but beyond this zone the 1000-cycle frequency is absorbed. Here again the area of Zones B and C are sufficient to provide proper coupling to the air for this 1000-cycle frequency. In Zone A only the 100-cycle frequency is present and this area is isolated from the rim by compliance rings and by the action of the fibers of a felt rim construction.

Actually this cone is not limited to three gradations of compliance, nor are the areas of different compliance sharply defined. The variation is a gradual one such that any frequency will be provided with active area to provide correct air coupling but beyond the limits of that area the energy is dissipated in the form of frictional heat developed in the compression and stretching of the fibers in the more compliant areas. In addition to the prevention of rim reflection this cone design provides high damping and as a result there is no troublesome overhang.

The Magnet

Having achieved a moving structure of the required characteristics there remained the problem of providing adequate magnetic flux to drive this large surface at the high velocities required, particularly in the reproduction of strong bass transients in which long axial travel of the voice coil is involved. At the very high frequencies it is also essential that the magnetomotive force be maintained at high level because although the amplitude of travel of the voice coil is minute, terrific velocities are attained and to change the direction of such rapidly moving mass involves considerable force.

An interesting illustration of the difference in response characteristics obtainable through improvement in magnet design is found by referring to Fig. 2. Curves 1 and 2 are for the same moving structure but with different magnets. Not only was overall efficiency increased but due to a characteristic of the special iron employed, the voice-coil impedance was maintained substantially constant up to 10,000 cps, with consequent radical improvement of response at this end of the range. In the final 27-inch speaker this special iron is utilized.

Figure 4 shows a section of the entire 27-inch speaker assembly with details of the design which provides flux density of 21,000 lines per sq cm in the gap. Such is the concentration of magnet metal that the complete pot with field coil weighs close to 450 pounds, of which the copper in the field coil contributes 65 pounds. The front plate of the magnet required special attention in order to maintain flux uniform even beyond the edges of the gap so that voice-coil excursions of $\frac{3}{8}$-in. in each direction could be experienced without variation of the field density. To accomplish this the front ring takes the unusual shape shown, extending as far as possible in the forward direction with just enough clearance to prevent being struck by the cone during maximum movements.

Also of interest in Fig. 4 is the detail of the felt rim assembly. It will be noted that compliance rings are provided only at the edge of the cone, the graduated compliance of the cone material itself making them unnecessary at other points. In addition to the rings a felt backing is also provided. This has been found to offer definite advantages in rapid damping of the lower frequencies, particularly in the case of powerful transients where hangover would be serious. The voice coil diameter is 6 inches, and the pot diameter 14 inches.

The curve of Fig. 1 shows the response characteristic of the final development mounted in a 1200 cubic-foot closed baffle. It will be noted that the response is flat within 8 db from 28 to 10,000 cps.

This speaker is intended primarily for mounting on a flat baffle (open or closed) of suitable dimensions. With such a baffle the efficiency is high and the frequency response approximately that of Fig. 1. Thus for normal high-power, high fidelity sound installations this combination provides an extremely effective reproducer system and one of the utmost simplicity inasmuch as it avoids the complications of space phasing where several speakers are employed and of properly blending the outputs of tweeter combinations.

Where higher efficiency is required (the efficiency of this speaker is already approximately 6 per cent higher than the typical smaller speaker) it can be economically obtained through the use of a horn baffle of good design. Such increased efficiency will be limited to the low-frequency end of the range and the addition of one or more auxiliary high-frequency speakers will be required to reestablish an overall flat response. But this may prove more economical than a general increase in power and speaker equipment sufficient to provide equivalent increased output.

NARROW BAND vs WIDE BAND in F-M RECEPTION

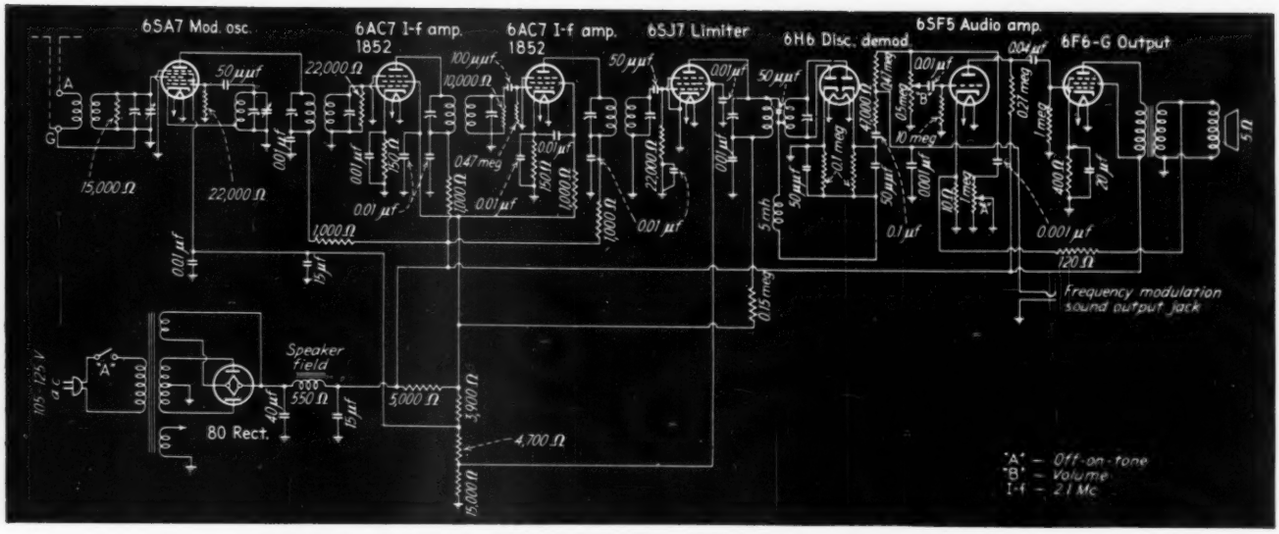


Fig. 1—Circuit diagram of the f-m receivers built for these tests. The set is essentially the same as the table-model converter unit now available commercially

By M. L. LEVY, *Engineer in Charge, Radio Development, Stromberg-Carlson Telephone Mfg. Co.*

THE results of constructing and measuring four frequency-modulation receivers using various degrees of transmitter swing provide the material for this article. The four f-m receivers were built identically in every respect with the exception of those factors which changed when various transmitter swings were used. The specifications used in the construction of the receivers are shown in the accompanying table. The frequency characteristic was designed to be flat to 10,000 cps within 6 db of that at 400 cps, overall. The circuit of these receivers appears in Fig. 1.

The transmitters used for the measurements are a Radio Engineering Laboratories 1000-watt unit used in conjunction with W8XVB in Rochester, N. Y., and a unit built in the laboratory of about one watt output for measurement purposes. The two transmitters were checked against each other. The laboratory unit was used only in those measurements which did not require large swings.

Discussion of Measurement Procedure

The transmitters were calibrated for frequency swing by beat methods to determine what audio voltage at the input of the modulator was necessary to produce the various swings desired. The calibration was made using an audio frequency of 100 cps. The actual calibration was made by using a wide band receiver and an oscillograph which allowed for accurate indication of band width along with audio beat note. The curves between frequency swing and audio voltage are linear over the ranges employed in the tests.

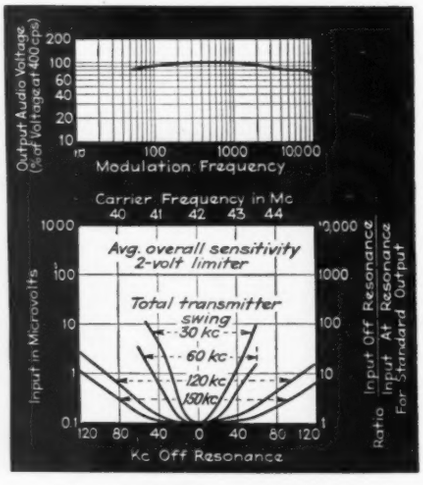


Fig. 2—Fidelity, sensitivity, and selectivity curves of the four receivers. The characteristics are identical except in the width of the acceptance band

All audio frequency measurements were made at the output of the discriminator or the output of the first audio stage which was a resistance-coupled stage. All noise measurements were taken using a potentiometer and an amplifier, in conjunction with a peak vacuum tube voltmeter and where necessary an oscillograph.

Harmonic distortion measurements were made with a General Radio harmonic analyzer and distortion factor meter. (It was found that 400-cps measurements on the distortion factor meter checked very closely the results of the harmonic analyzer and in most cases these measurements were used.)

The measurements show:

1. *The frequency characteristics* (Fig. 2) of each of the four systems measured are similar *i.e.*, there seems to be no limitation in providing a good frequency characteristic with any system of transmitter swing.

2. *The overall distortion* (Fig. 3)

Results of tests conducted by Stromberg-Carlson to determine the relative merits of employing frequency swings of 150, 120, 60 and 30 kc for frequency modulation reception, reported to the Federal Communications Commission at the f-m hearing

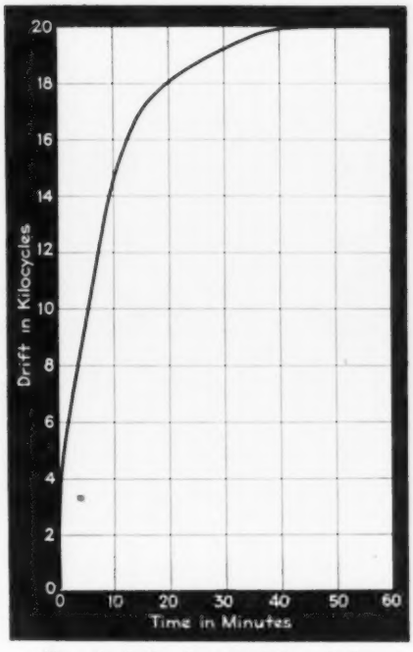


Fig. 4—Drift characteristic of the oscillator used in the four test receivers

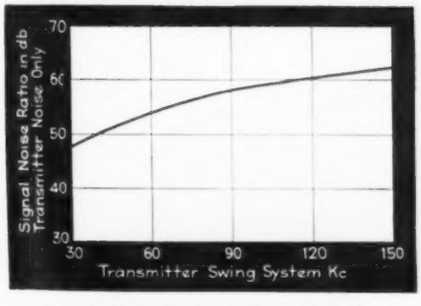


Fig. 5—Signal-noise ratio as a function of frequency swing employed, taken with filters to eliminate hum

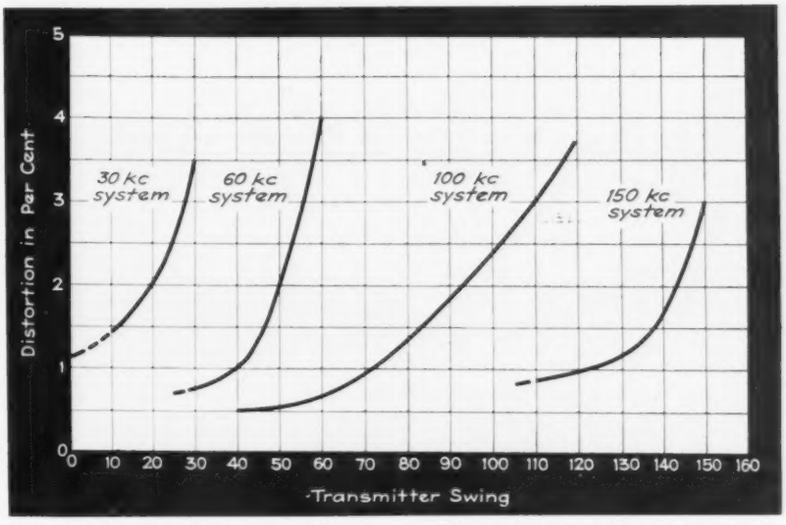


Fig. 3—Overall distortion as a function of percentage modulation, which corresponds with the transmitter swing, for the four degrees of frequency swing

in each case is the same order of magnitude.

3. *The drift* (Fig. 4) in each of the four receivers is obviously the same since that portion of each receiver is identical.

4. From the standpoint of practical operation, the *drive ratio* must be increased proportionately to obtain the same "ease of tuning".

5. *The signal-to-noise ratio* (Fig. 5) decreases when the transmitter swing system is reduced. The signal to noise ratio of 150 kc swing system is about 62 db (transmitter noise only) whereas with a transmitter swing system of 30 kc, the signal to noise ratio is 48 db and 60 kc swing system is 54 db. The separate receivers designed for the various transmitter swings were used in these measurements. It is noted here that regardless of any external noise these differences are always present, because under the conditions of measurements the receiver noise at relatively strong signals is not measureable. So that, under ideal conditions these measurements show the optimum signal-noise ratio obtainable under these various conditions of transmitter swing. There is the possibility of reducing the transmitter noise somewhat in narrow band transmitters but to date this has not been accomplished. Also, the signal-noise ratio in any given system is dependent entirely upon the amount of audio voltage available which is, of course, greater with systems of greater transmitter swings.

Figure 6 shows the results of introducing fluctuation and impulse noise. The fluctuation noise was generated by using a 3-stage amplifier at 2100 kc fed into the modulator grid. The noise was controlled by controlling the gain of the amplifier. The noise was calibrated by means of signal generator at 43 Mc and the limiter grid current. The measurements were made by means of a potentiometer in the output circuit of the audio amplifier tube and an external amplifier following the potentiometer. The indicator was a vacuum tube voltmeter and an oscillograph. These measurements show that the wider the band at the levels used (which was about 300 microvolts of noise introduced) considerably greater noise suppression is accomplished.

The amplitude modulation curve on Fig. 6 was obtained by converting the 30-kc receiver to amplitude modulation; using the limiter as the audio (amplitude) detector, this gives a direct comparison of f-m and a-m on the same receiver under exactly the same conditions. The result is that for amplitude modulation 100 times the carrier is required to produce the same noise reduction as is obtained with f-m at 150 kc swing with carrier over noise of 2 to 1. Reducing the swing decreases the ratio relative to the 150 kc case but it is shown that even 30 kc swing shows a substantial improvement over amplitude modulation.

The impulse noise was generated by means of a vibrator unit used

ordinarily in battery power supplies. This noise was calibrated in a similar manner to the fluctuation noise except that the oscillograph was used exclusively for determining peak values. The results here show approximately the same differences in noise suppression for 30 kc and 150 kc as were found on the fluctuation noise. Due to the difficulty in calibration of impulse noise only the two extreme measurements were taken.

In a practical system of 150 kc swing, a signal-to-noise ratio of 62 db is barely sufficient to provide quiet operation when the audio amplifier and the speaker system have a flat characteristic from 50 to 10,000 cps. Therefore, any system which is less than 62 db would be correspondingly poorer under any conditions. Reference is made here to the Stromberg-Carlson type 480 receiver which when operated on a system of 150 kc swing has a noticeable amount of noise when the system is "wide open". The type 480 receiver has been designed to provide not only flat audio response throughout the range of 50 to 10,000 cps, but also flat "acoustic" response measured by recognized methods. Any system of less swing than 150 kc will further decrease the signal-noise ratio, so that steps would have to be taken to reduce the overall audio range on account of the additional noise. The measurements as taken in Fig. 5 limit the noise to that of the transmitter only, when the signal is amply strong to operate the "limiter" solidly. The fact which suggests itself is that the transmitters must be made quieter than they are at present to do justice to the system even at a transmitter swing of 150 kc. This work is being done and a further noise reduction of 10 db in the transmitter is now possible which will greatly improve the system. Any system of less swing than 150 kc, moreover, reduces the possibility of future development for better quality at lower cost, since each time the transmitter swing is reduced, the audio output available at the receiver is less and the noise remains about the same at the transmitter with the result that reduction of the higher frequency response is necessary to keep the noise down to a practical level.

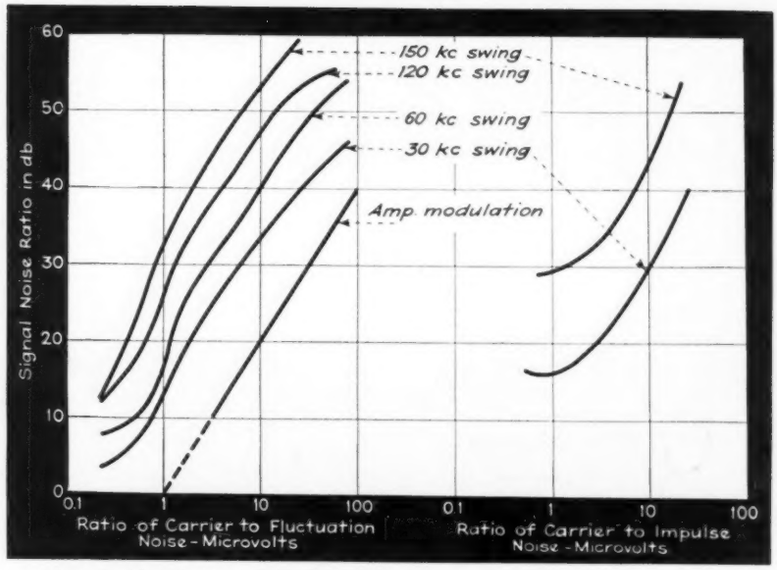


Fig. 6—Signal-noise ratio against impulse- and fluctuation-type noises at various relative carrier levels, for various frequency swings and for amplitude modulation

The factors in receiver design which contribute to the signal noise ratio are as follows:

The *sensitivity* of the receiver, which allows the limiter to operate at a definite point. The f-m receivers because of their inherent noise reducing features are designed for much greater sensitivity than would be possible in an a-m system. The reason for this is that the tube noises of a receiver are of amplitude variety and are not detected by the frequency detector. Therefore, the greater the sensitivity, the quicker the receiver is rendered quiet by low field strengths, by its limiter and detector action. It also follows that a much weaker signal is usable with

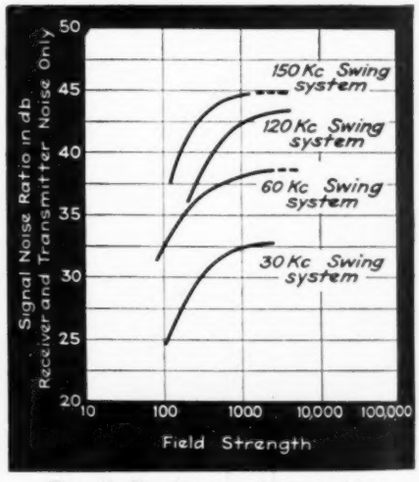


Fig. 7—Receiver and transmitter noise ratio as a function of input signal strength

an f-m receiver than with an a-m receiver at the same frequency. Sensitivity contributes to noise in an amplitude modulated receiver and reduces noise in a frequency-modulated receiver. Therefore, frequency modulation receivers must be quite sensitive to reduce receiver and external noises at low field strength. Commercial receivers of the future will probably have sensitivities of the order of 10 microvolts for full limiting. Figures 7 and 8 show the noise ratio and limited output voltage, respectively, at various input signal levels.

Transmitter Total Swing.....	30 kc	60 kc	120 kc	150 kc
Assumed Channel Width (Total).....	40 kc	80 kc	160 kc	200 kc
Selectance Ratio = 5@.....	±20 kc	±40 kc	±80 kc	±100 kc
Selectance Ratio = 2@.....	±15 kc	±30 kc	±60 kc	±75 kc
Harmonic Distortion at full swing....	5%	5%	5%	5%
Tuning Range.....	40–44 Mc	40–44 Mc	40–44 Mc	40–44 Mc
Discriminator Characteristics linear for	±15 kc	±30 kc	±60 kc	±75 kc

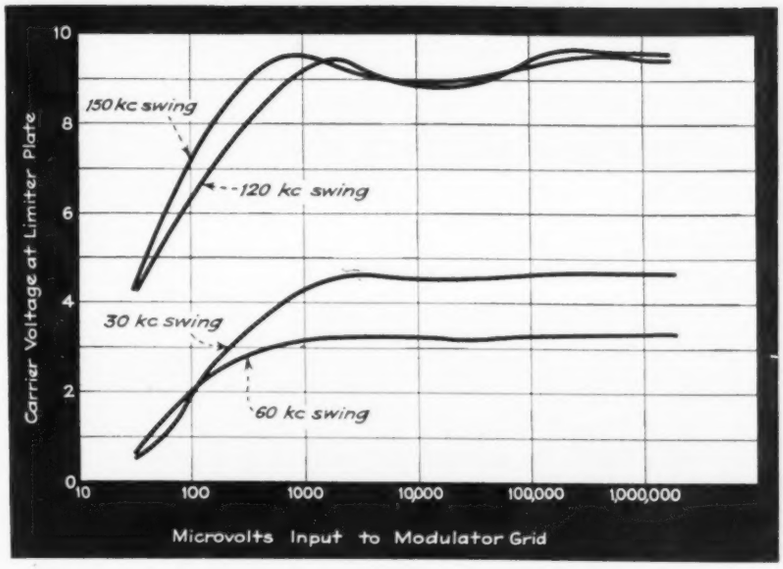


Fig. 8—Limiter operation, measured as output carrier voltage in terms of input signal at the frequency-converter grid

Figure 9 shows the result of operating two transmitters on the same frequency. The measurement was made by tuning in a signal 50 per cent modulated (one half the total swing) called the undesired signal. This signal level was held constant. The desired signal on the same frequency was then applied unmodulated and the reduction in audio voltage of the undesired signal was measured as the desired signal strength was increased. Figure 9 is plotted in db similar to signal-noise ratio characteristics. This method of measurement was used because of the better accuracy obtainable with existing equipment. The curves show that with 150 kc transmitter swing system, when the desired signal is twice that of the undesired, the interfering signal is reduced about 26 db (this checks very closely with the curves of fluctuation noise). At the other extreme, 30 kc swing, about 15 times the signal is required to produce 26 db reduction of the interfering signal.

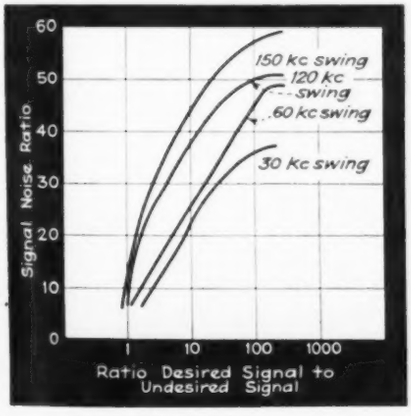


Fig. 9—Ratio of undesired to desired signal on the same channel, for various carrier levels and frequency swings

Two Stations on Adjacent Channels

Figure 10 shows the results of adjacent channel measurements. In this, as all other cases, the measurements were made in a similar manner to the two stations on the same channel, except that the audio reduction of the desired signal was plotted.

The procedure was as follows: In each case 50 per cent modulation was used on the desired signal and the signal on the adjacent channel was unmodulated for the series of curves on the left and 100 per cent modulated (that is, full swing for the particular system) for the curves on the right. The results show the reduction of audio voltage of the desired signal when the undesired signal strength on the adjacent channel is increased. The curves show that the 150 kc swing system produces much less interference for a particular ratio of undesired to desired signal in all cases.

Ease of Tuning

The American public has been supplied to date with receivers which tune easily and quickly. The receiver designed for transmitter swing of 150 kc tunes manually with greater ease than the standard receiver in the broadcast band. Further, tuning indicators can be provided which will be quite broad, and accurate tuning is not a chore. Comparing this to the receiver designed for a transmitter swing of 30 kc, the tuning is critical and so are the tuning indicators, even with increased drive ratio. As a matter of experience, the receiver designed for transmitter swing of 150 kc can be tuned quite readily without a tuning indicator. The receiver designed for transmitter swing of 30 kc would not be practical at the present state of development without a tuning in-

(Continued on page 97)

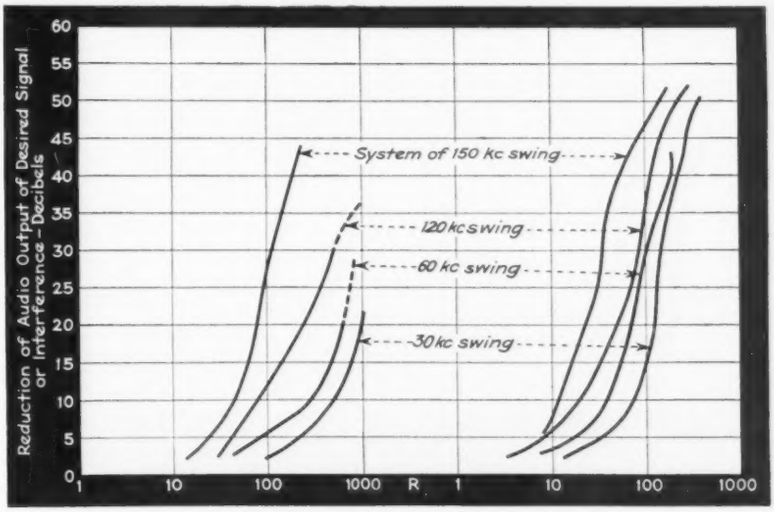

System of 150 kc swing
120 kc swing
60 kc swing
30 kc swing
Reduction of Audio Output of Desired Signal or Interference - Decibels
R

Fig. 10—Ratio of undesired to desired signals on adjacent channels, with channel separations 33 per cent larger than the frequency swing. At left with unmodulated undesired signal, right with 100 per cent modulation, desired signal modulated 50 per cent in both cases

A Picture Signal Generator—III

In this third installment the mixing amplifier, which combines the synchronizing, blanking, and picture-signal components, is described together with a line amplifier. The shading-signal generator, which produces compensation for the dark-spot is also discussed

By J. A. Brustman and

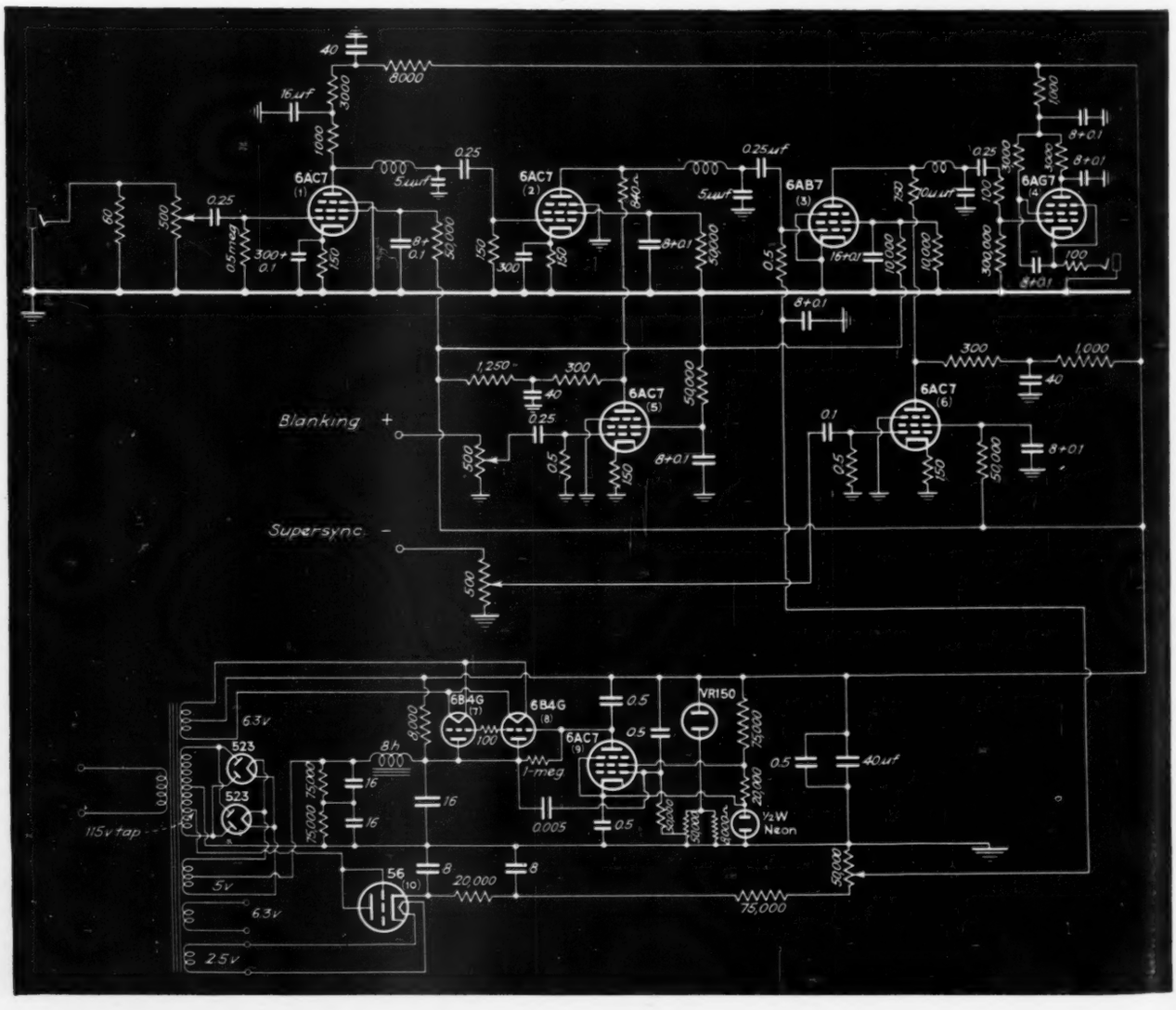
M. P. Wilder

American Television Corporation

IT is the function of the mixing amplifier to assemble the various components of the video signal, with the exception of the shading voltages. The shading signal is best inserted in the video preamplifier where it can be inserted at as low a level as possible. The major portion of the amplitude characteristic of subsequent amplifiers may then be devoted to the amplification of the corrected video signal without danger of overload and the resultant loss in picture contrast, which would occur if the shading signals were inserted at a later point near the end of the video amplifier chain.

Shading signals are necessary to suppress spurious signals inherent in the operation of the conventional iconoscope. These signals must be neutralized or bucked out by voltages of similar waveform but opposite in phase. The shading unit to be described in this article is capable of developing a wide variety of waveforms all equal in frequency to either the line or the field frequency.

Fig. 1—Mixing amplifier and regulated power supply. The power supply shown also serves the shading-signal generator



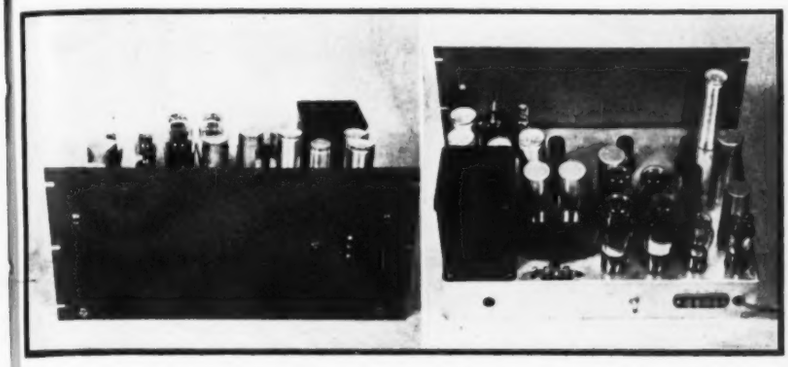


Fig. 2—Front and rear views of the mixing amplifier chassis and its regulated power supply. This equipment combines the sync signals, blanking signals, and the output of the camera into the video signal

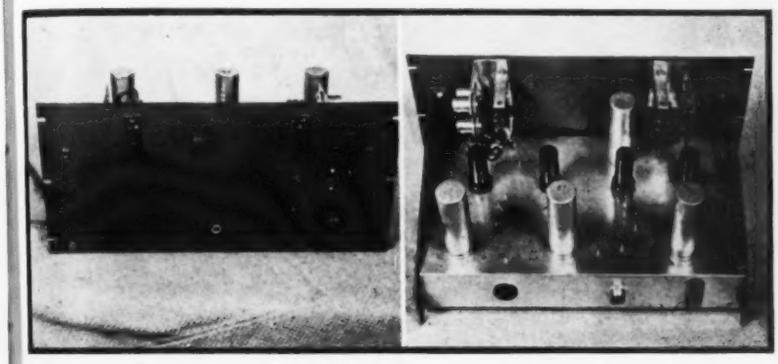


Fig. 3—Coupling circuits for video amplifiers (A) series peaking, (B) combined coupling network

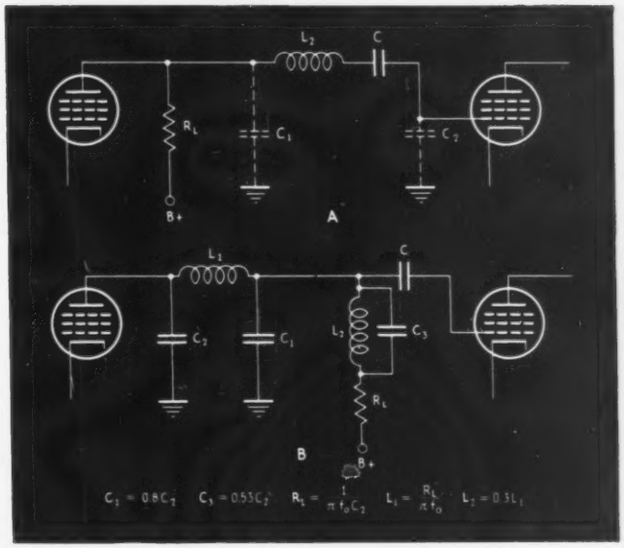


Fig. 4—Left, front and rear views of the line amplifier. The switches allow the selection of either the television receiver or the output of the local camera and generator

These may be controlled as to amplitude and phase and assembled for insertion in the cathode circuit of the first tube of the preamplifier. The proper waveform will be dictated by whatever is necessary to balance dark spots appearing on the picture monitor tube and at the same time allow maximum contrast or range of tones in the picture.

The picture component of the video signal, complete with the shading signals, is obtained from the output impedance of the cathode-coupled stage (cathode follower) in the camera preamplifier and transmitted by coaxial cable from an apparent 60-ohm source to the input of the mixing amplifier. The output of the camera preamplifier is of the order of 0.1 volt. It is applied to the grid of tube No. 1 in Fig. 1 and controlled as to amplitude by the potentiometer across the sixty-ohm terminating resistor.

The first stage in the mixing amplifier serves to amplify the output of the preamplifier and apply it as a negative signal to the grid of the second tube in whose plate circuit the blanking pulses will be inserted. The polarity of the blanking pulse on the grid of tube 5 is positive. The plate of this tube is connected part way up the load resistor of tube 2. It is quite important to assemble signals in the proper phase relation. Furthermore, as we wish to clip the top off the blanking pulse in tube 3 by driving its grid beyond plate current cutoff, the blanking pulses must be negative in sign. It will be noted that series peaking of the high frequencies and anode compensation of the low frequencies by suitable choice of decoupling resistors and bypass condensers is used (see Kimball and Seeley, *RCA Review*, January 1939). The supersync is added in the plate of tube 3 by insertion in the plate circuit of tube 6 again by the common anode resistor method. The amplitudes of both blanking and supersync are determined by potentiometers in the grid circuits of tubes 5 and 6.

The output of type 3 plus the supersync is then applied to the grid of the output stage, then cathode-coupled to the grid of the line-amplifier first stage. It will be noted that a separate grid-bias rectifier is included in the regulated power supply. The B supply is similar to that shown in Fig. 5 of the first article of this series. It is reprinted here in the interest of clarity as there were several drafting errors in the circuit diagram shown in the first article.

The line amplifier consists of three stages and a cathode coupled output stage which feeds the final two stages as well as two other sources such as the kinets, in different parts of the laboratory and the r-f modulator and oscillator on 45.25 Mc for the receiver design test department. The output stage feeding the kinet is unique in that it employs a very high load resistor for the band width of 6 Mc. This is possible by employing an M-derived ½-section plus a full constant-K section filter. If this type of coupling is employed careful measurement of all *L*, *C*, and *R* values is necessary. If a similar fil-

ter is employed the circuits in Fig. 3B should be used. This filter is suitable for an output stage but not recommended for more than two cascaded stages since cumulative phase shift will become excessive and no longer proportional to frequency.

Formulas for series peaking

The circuits in Fig. 3A show representative "series-peaking" circuits used in the video amplifier. Among the conditions which apply to the use of this circuit are:

(1) For the best operation of this filter $C_2/C_1 = 2$. (2) The load resistor can be placed on either side of the filter and should be placed on the side with least capacitance. (3) The load resistance is

$$R_L = \left(\frac{1.5}{\pi f_o C_t}\right)$$

where

$$C_t = C_1 + C_2$$

and f_o is the maximum video frequency to be amplified. (4) The inductance L_2 equals $0.67\ C_1\ R^2_L$. The phase shift, according to Kimball and Seeley, is $\frac{.0113}{f_o}$ seconds at frequency f_o, in Mc. The capacitances must be measured accurately by a Q meter or some other method and additional capacity added to C_1 or C_2 to make $C_2/C_1 = 2$.

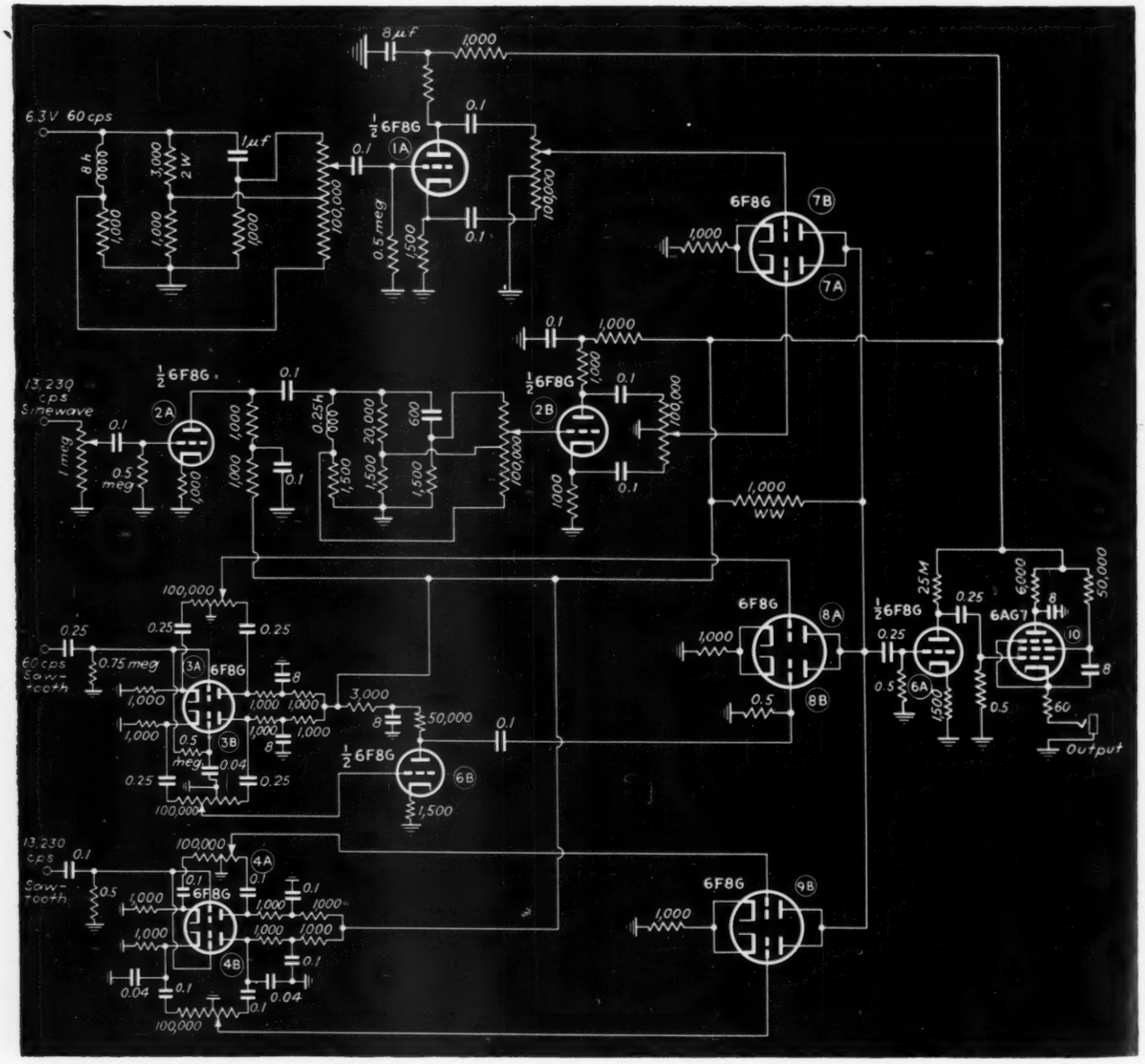
The formulas given in Fig. 3B apply to the elements of the M-derived plus constant-K low pass filter, referred to previously.

The filter may be reversed but the side containing the load resistor section should be placed across the smaller residual capacitance. As an example for a 4.2 Mc cutoff, the values are $C_2 = 15.2\ \mu\mu f$, $C_1 = 12.16\ \mu\mu f$, $C_3 = 8.1\ \mu\mu f$, $R_2 = 5000$ ohms, $L_1 = 379\ \mu h$, $L_2 = 113.7\ \mu h$.

Shading Signal Generator

Three fundamental wave forms are available for shading: (1) 60 and 13,230 cps sine waves whose phase may be shifted continuously

Fig. 5—Diagram of the shading-signal generator, which produces synchronized sawtooth, sine, and parabolic waves to remove the dark spot signal from the iconoscope output



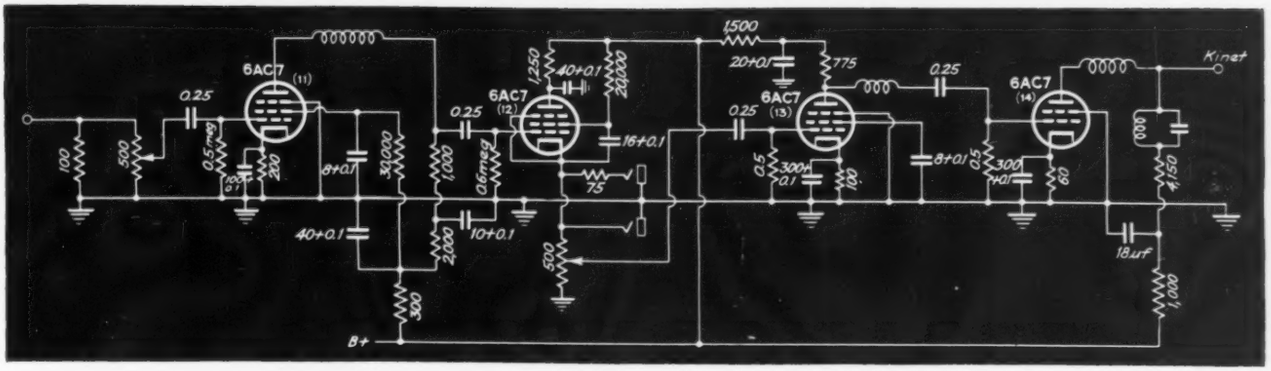


Fig. 6—The line amplifier which increases the level of the composite video signal so that it can control a picture tube directly

Fig. 7—Rear view of the shading-signal generator. Eight double-triode tubes are used to develop the correction signals to remove the dark spot

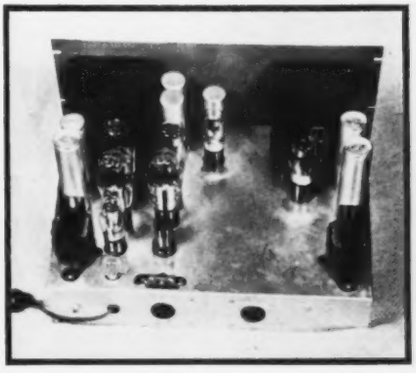


Fig. 8—Rear view of the power supply which provides voltages for the shading-signal generator, as well as for the iconoscope sweep circuits shown in Part II

Fig. 9—Mr. H. C. Kreinick of the American Television Corporation staff, televised by the equipment and reproduced on the monitor screen

through 360°, (2) 60 and 13,230 cps parabolic waves whose signs and amplitudes are reversible, (3) 60 and 13,230 cps sawtooth waveforms whose signs and amplitudes are reversible. In the grid circuit of triode 1A, Fig. 5, is a network of *L*, *R*, and *C* so arranged as to shift the phase and amplitude of the 60 cycle ac arriving on the grid by means of a potentiometer. In the cathode and plate circuit of 1A a potentiometer will allow control of the amplitude and phase. The output appearing ultimately on the grid of tube 6A along with all other wave forms.

Triode 2A amplifies the 13,230 cps sine wave output of the timer and applies it to a net work for phase shift by a potentiometer across its output in the grid of triode 2B where phase and amplitude can again be shifted 180° before passing on via 7A to the assembly point at the grid of 6A.

Sixty cycle sawtoothed waves from the iconoscope sweeps, see Fig. 7 article No. 1 this series, is applied to the grid of 3A to appear as a sawtoothed wave whose amplitude is reversible and continuously variable, before applying to triode 8A for assembly and reappearance with all others at 6A. At the same time this sawtooth is predistorted in the grid of 3B to obtain a parabolic wave which is passed on to tube 6B and amplified in like manner to 6A. The amplification is required because in distorting the waveform the amplitude is lowered and must be raised to the equivalent level of the other waves appearing at 6A.

Triode 4A has appearing on its grid a 13,230 cps sawtooth wave which is adjustable in similar manner to the others in the plate of 4A and appears with all others on the grid of 6A. The 13,230 cps sawtooth waveform is also predistorted to a parabolic form but in a somewhat different way. In this case in the plate and cathode circuits to form a parabolic wave which is passed on via 9A to meet the others at 6A. The output of 6A enters on the grid of a cathode follower for impedance transformation in tube 10 and appears in its cathode at the point marked output. A study on an oscilloscope of all these wave forms at their origin and on through their respective paths will be self explanatory. Final adjustment and utilization will depend on the particular scene that is being shaded. The proper adjustments being determined by trial and error. Aptitude for this adjustment develops with surprising speed.

The next article in this series will be on the monitor tube sweeps, power supply, and the waveform oscilloscope.

Editor's Note. In addition to the correction above noted to the regulated power supply diagram appearing in Fig. 5, Part I of this series, which is shown correctly in Fig. 1 of this installment, a correction should be made to the diagram of the high voltage power supply for the iconoscope, shown in Fig. 5, Part I. The polarity of the type 879 rectifier should be reversed so that the anode connects directly to the filter circuit, thus making the terminal marked *K* negative with respect to the terminals marked *G*, A_1 and A_2.

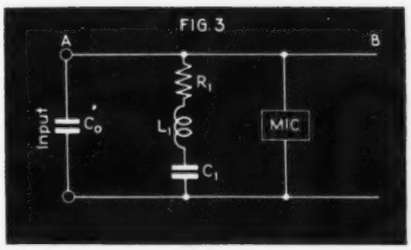


Fig. 3—Equivalent circuit of the artificial ear, including capacitive input and a damped series resonant circuit

the diaphragm vibration without the undue loss of pressure at low frequencies which would result if the damping holes opened directly into the air. The equivalent electrical circuit of this acoustical system is shown in Fig. 3. C_0 represents the compliance of the auricular volume. *AB* represents an open-circuited line of distributed constants representing the ear canal. R_1 and L_1 represents the resistance and inertance of the damping holes. C_1 represents the volume of the auxiliary chambers. *M* is the microphone which is substantialy pressure actuated, its impedance being high (resonance above 10,000 cps). The design of the damping holes follows the theory developed by Sivian (*Jour. Acous. Society*, 7, 96, 1935) and has been checked experimentally through the velocity range likely to be encountered in test work. The canal is equal in diameter and length to that of the average human ear and its high-frequency resonances may be expected to duplicate those of the actual ear. Since practically nothing is known about the resonances in the human ear this is purely an heuristic conjecture. These higher frequency resonances are controlled by the damping effect of cotton packed loosely in the canal. The design has been checked by means of a constant amplitude piston placed in the plane of the auricular opening. This procedure is also employed for calibration.

The microphone is of the crystal (Rochelle-salt) type manufactured by the Brush Development Company. It is well known that the output of such microphones is somewhat dependent upon the temperature, having a maximum at about 23.5° (upper Curie point). For this reason no attempt is made to make a per-

(Continued on page 108)

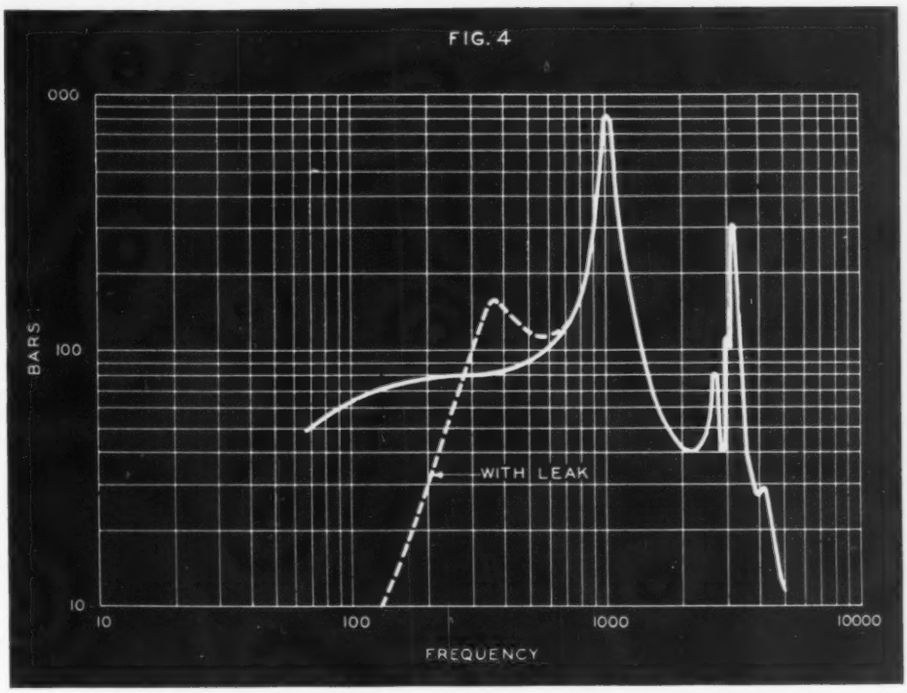


Fig. 4—Sound output vs frequency of a typical commercial telephone receiver. The dotted line shows the effect of air leakage

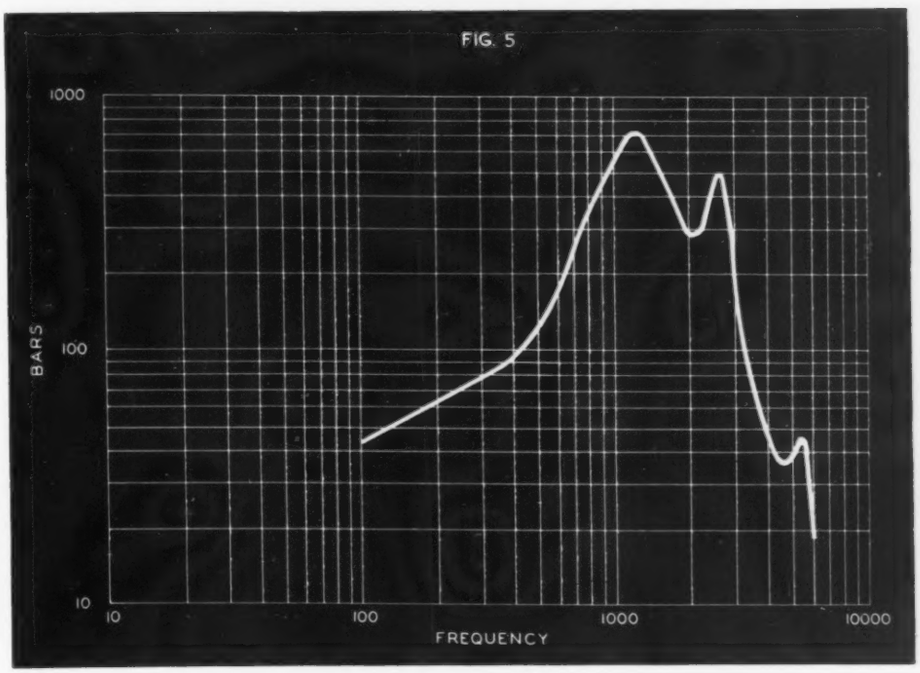


Fig. 5—Sound input vs frequency of a typical commercial hearing-aid receiver. Note the high energy content above 1000 cps

RECEIVER TESTING WITH AN "ARTIFICIAL EAR"

By STUART BALLANTINE
Ballantine Laboratories, Inc.

The acoustic output of a telephone receiver or hearing aid reproducer depends on the "acoustic network" into which it works. Dr. Ballantine describes such a network designed to simulate the human ear and hence to provide an unvarying standard for testing

Fig. 1—The artificial ear, shown above, consists of the acoustic chamber, a pressure-operated microphone and an electronic voltmeter to measure the microphone voltage

ALTHOUGH the telephone receiver has been in use for over half a century, only comparatively recently have satisfactory methods become available for measuring its electroacoustic performance under conditions simulating those which exist when the receiver is held against the ear. Its efficiency is measured by the acoustical pressure developed at the ear drum for a given electrical input. Of equal interest is the variation of this acoustical pressure with frequency over the audible range, for a given electrical input. This frequency response characteristic enables us to estimate the fidelity of reproduction. Such information may be obtained with the aid of an "artificial ear", which is a physical model of the human ear which simulates its acoustical properties. The artificial ear has an advantage over the use of actual ears for test purposes in that it avoids the wide variation between individual ears and has acoustical properties which remain constant from day to day, thus furnishing reproducible results. Although this device and method are not new (see bibliography) suitable apparatus is to be found only in a few highly specialized research laboratories and has not hitherto been commercially available. The artificial ear described here has been developed to fill this need. In this design every effort has been made toward simplicity and low cost in order that the instrument may enjoy wide use for routine production and service testing as well as for research work.

The new artificial ear is designed for use with Ballantine Model 300 Electronic Voltmeter (*Electronics*, page 33, September, 1938) or any voltmeter reading down to 1 millivolt and having the same input impedance (500,000 ohms shunted by 30 $\mu\mu$f). This combination is illustrated in Fig. 1. The sensitivity is such that the voltmeter reads 1 millivolt for a sound pressure of 20 bars (dynes/cm^2).

The artificial ear coupler is shown in cross-section in Fig. 2. This is designed to simulate the acoustical characteristics of the human ear, also shown in Fig. 2. Its design is based upon measurements of ear acoustical impedances made by West Troeger,[2a, 2b] Inglis, Gray and Jenkins,[4] and by the author. The conical cavity *A* in the molded rubber piece simulates the volume of the auricula *A'*. This piece is molded of rubber, which simulates the elasticity of the ear muscle and also aids in obtaining a tight seal when the telephone receiver is placed upon it for measurement. The ear canal (external meatus) *B'* is simulated by the canal *B* in the artificial ear. This canal is terminated by the acoustical resistance *F* and the microphone *M*. The acoustical resistance *F* comprises several small holes opening into the auxiliary chambers *D*. This resistance effectively damps

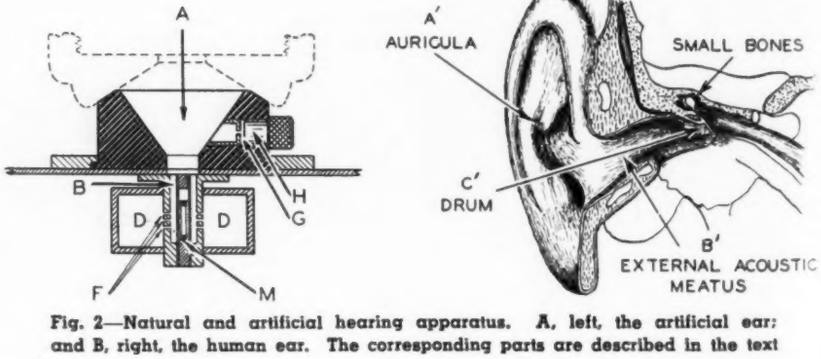


Fig. 2—Natural and artificial hearing apparatus. A, left, the artificial ear; and B, right, the human ear. The corresponding parts are described in the text

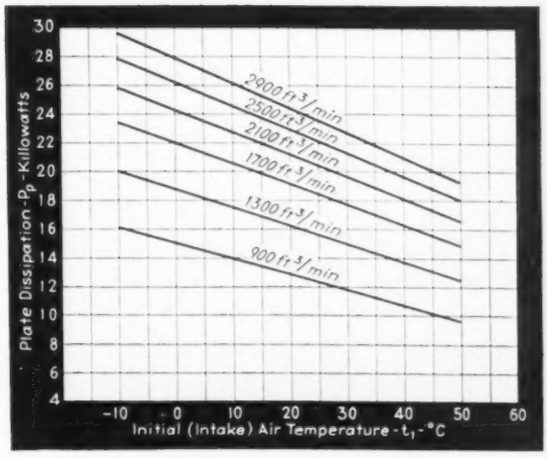


Fig. 3—Air requirements for types F124-A and F125-A, showing plate dissipation limit for various volume air-flow rates and initial temperatures

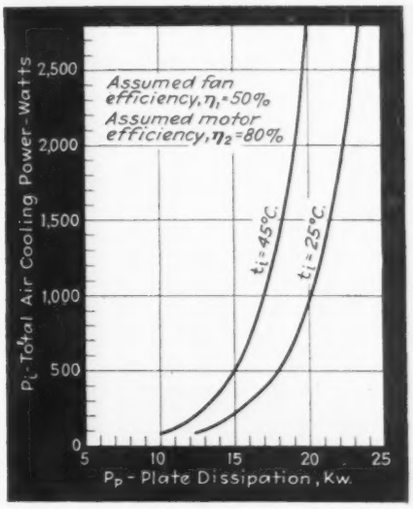


Fig. 4—Power required to cool air for various plate dissipation ratings of the F124-A and F125-A

to reduce electrolytic corrosion and power loss due to leakage current. Use of distilled water involves a closed circulating heat exchanger system with the incident water pumps, cooling fans, radiators and associated equipment. Expensive insulating hose reels or piping are also required to isolate the anode circuit from ground. In spite of all these precautions considerable maintenance of such a system may be inevitable.

In contrast with such an installation the requirements of forced-air cooled tubes are relatively simple. A low pressure centrifugal fan easily insulated from the tube serves to circulate air through its cooling fins. In most cases a very simple air circulation system serves to maintain input and station air temperature at the required values.

Principles of Forced-Air Cooling

In considering methods of forced-air cooling a rough division may be made between high and low pressure systems. The tubes under consideration here are of the low-pressure air-cooled type, that is, they are cooled by a stream of air of relatively high velocity and large volume, but at approximately atmospheric pressure. We shall consider briefly the basic principles of such low pressure air cooling. A detailed analysis is given by Van de Beek, in the *Philips Technical Review*, Vol. 4, No. 5, May, 1939.

Knowing that the specific heat of air at atmospheric pressure is equal to 456 joules per lb/deg C., we may write the expression for the air-flow, W, in lbs per min required to dissipate a power of P kilowatts for an air temperature rise Δt degrees Centigrade as

$$W = 131.5\ P/\Delta t \qquad (1a)$$

This may be written in terms of volume of air-flow, Q, in cubic feet per minute for a given initial air temperature, t_i, degrees Centigrade, as

$$Q = 5.92\ (t_i + 273)\ \frac{P}{\Delta t} \qquad (1b)$$

The graphs of Fig. 1 and 2 show respectively the relations between cooling-air volume, weight and initial temperature and between kilowatts dissipation, rate of air-flow and cooling-air temperature rise. From them we see that it is entirely possible for practically obtainable values of air-flow and input air temperature to dissipate the large quantities of power in which we are interested.

We must now ascertain the efficiency with which heat may be transferred from the heated metal anode surface to the cooling-air stream in order to determine the radiator surface area which will be required. The power, P, in watts delivered to the cooling-air is given by the formula

$$P = hS\ (t - t_a) \qquad (2)$$

where h = the coefficient of heat transfer, watts/sq ft
S = the cooling surface area in sq ft
t = the temperature of the cooling surface, deg C.
t_a = the average temperature of the air, deg C.

Since $t_a = t_i + \frac{\Delta t}{2}$ we may write Equation (1b) as

$$P = \frac{hS\ (t - t_i)}{1 + 2.96\ (t_i + 273)\ \frac{hS}{Q}} \qquad (3a)$$

The surface coefficient of heat transfer, h, is substantially independent of the nature of the cooling surface for the turbulent flow encountered at the relatively high air velocities used. It is given by the expression

$$h = 0.259\ V^{0.78}\ \text{watts/sq ft} \qquad (3b)$$

Where V = cooling-air velocity in feet per second. Equation (3a) enables us to calculate the watts dissipating ability of an anode of total cooling surface area, S square feet, at the uniform surface temperature t° C.

Since there is an unavoidable temperature drop through the radiator due to thermal resistance, in the practical application of Equation (3a), t must be taken as an average temperature. The internal radiator temperature relations may be expressed by the formula

$$T - t = \frac{l}{kA}\ \text{deg C.} \qquad (4)$$

Where k = the specific thermal conductivity of the radiator material
T = anode temperature
t = average radiator temperature
l = average length of heat conduction path in inches
A = cross-sectional area of heat conducting path in square inches

Air Cooling Applied to External-Anode Tubes

By E. M. OSTLUND
Tube Engineering Dept. Federal Telegraph Company

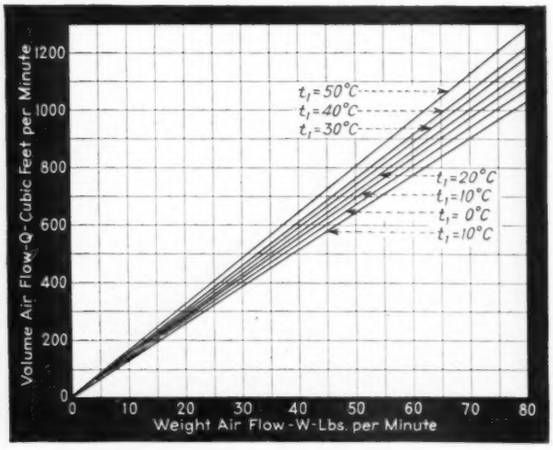


Fig. 1—Relationship between volume and weight of airflow for different initial air temperatures

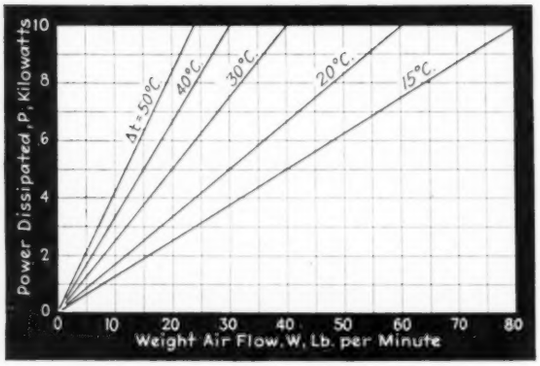


Fig. 2—Power dissipation as a function of the weight of airflow for given values of air temperature rise

The trend to air cooling as a cheaper and equally effective substitute for water cooling of high-powered transmitting tubes has now extended to dissipation ratings in the tens of kilowatts. Here is presented a review of the fundamental theory and typical applications by an engineer actively engaged in transmitting tube development

THE recent trend toward refinement of transmitter design, with its stress upon high overall efficiency and elimination of auxiliary equipment, has given impetus to the development of the new forced-air-cooled type of transmitting tubes. These tubes are of great interest to the transmitter engineer because they offer ease of application comparable to that of the radiation-cooled type together with the high power-output characteristic of water-cooled tubes. Some information relative to their design and application should therefore be of interest.

The dissipation of anode heat generated in transmitting tubes is a fundamental factor governing their design and application. Failure to provide proper cooling results in excessive operating temperatures of the tube structure with ensuing liberation of gas and consequent failure of the tube. Two methods of anode cooling have been widely used in the past, radiation cooling and water cooling. The third method, more recently applied, is direct forced-air cooling. The specific dissipation capabilities and anode operating temperatures of the three methods are approximately as follows:

Type of Cooling	Specific Dissipation Capability watts/sq inch	Typical Anode Operating Temperature deg C
Radiation..	25- 50	400-1000
Water.....	200-700	30- 60
Forced-Air.	3- 4	150- 200

Since the anode of radiation-cooled tubes is mounted inside of an evacuated glass envelope, and its size and operating temperature are limited, such tubes are practical only for relatively low outputs. Water-cooled tubes with their high specific dissipation capability and low anode operating temperature have been universally used for high power amplification purposes. Like water-cooled tubes, forced-air cooled tubes are capable of high power outputs although their specific anode dissipation capacity is low since the size of their anode structure is not restricted as in the case of radiation-cooled tubes. Their low anode operating temperature affords the same manufacturing and operating advantages, as in the case of water-cooled tubes.

Operating Advantages of Air-Cooled Tubes

Water-cooled tubes require extensive auxiliary equipment expensive in first cost and in maintenance charges. Distilled water must be used where cooling water impurities are present, to avoid destructive precipitation of scale on the anode and

shock-absorbing ring or gasket should be used to cushion-mount the radiator.

Electrical Characteristics

In general the forced-air-cooled tubes available at present have electrical characteristics identical with the equivalent water cooled types with the exception of plate power input and dissipation maximum ratings, which for usual radiator construction are approximately 50 per cent of water-cooled values. It is apparent that in high efficiency plate modulated broadcast transmitters where peak plate current and voltage swing are the limiting factors, the same power output as that of their water-cooled prototype may be obtained since the designed maximum plate dissipation capability is not required. Forced-air-cooled tubes have been used in standard broadcast transmitters of medium output power for some time where they have given unusually efficient and reliable performance. Their use in higher output transmitters has been contingent upon the adoption of high efficiency circuits of this rating. In the case of class B linear and grid-bias modulated transmitters where plate dissipation is the limitation, a larger number of forced-air-cooled tubes will normally be required to replace a given number of water-cooled tubes. For this reason the air-cooled tube will only give most economical performance with modern high efficiency installations, although the saving over water-cooling costs may also make their use practical in low efficiency circuits.

As mentioned above, forced-air-cooled tubes have definite advantages for high frequency operation. At these frequencies losses in grid leads, seals and envelope cause excessive heating of these parts and often constitute the operating limitation. Cooling of these parts by the exhaust air stream eliminates the necessity for an auxiliary blower to insure safe operating temperatures. The anode-ground shunting capacity of a forced-air-cooled radiator is approximately the same as that of the equivalent water jacket with its associated piping.

Operation

Operating precautions to be observed in the use of forced-air-cooled tubes are in general analagous to those of water-cooled tubes. The published maximum electrical ratings must be rigidly observed. A continuous flow of filtered cooling air must be maintained. The minimum required rate of flow for the maximum inlet air temperature during operation is determined from the cooling requirement chart (see Fig. 3) for the given tube. Protective devices must be provided to prevent the application of filament or plate power in the absence of rated air flow.

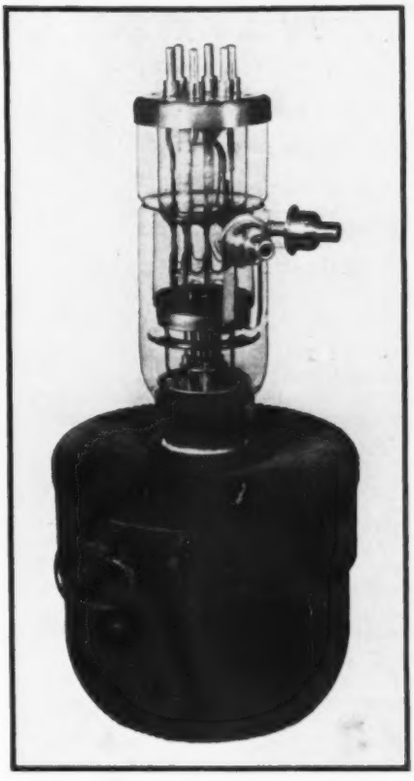
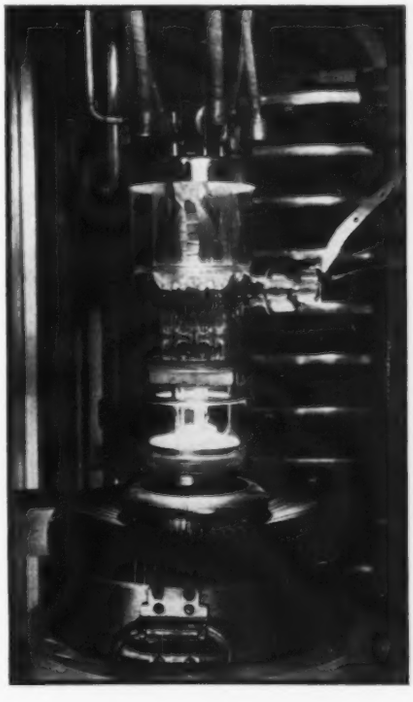


Fig. 6—Typical forced-air cooling tube showing finned anode assembly (type F124-A)

Fig. 7—Air-cooled tube in operation at the transmitter of WBBM, Chicago



The use of air-cooled tubes requires relatively simple special structural features in the design of station house and arrangement of equipment. Figure 5 shows suggested layouts for small and large transmitters. Fan duct intake and exhaust openings must be so arranged as to assure the maintenance of a safe inlet air temperature to the tube under all ambient temperature conditions. In most climates this can be accomplished by a very simple recirculation system. From Fig. 5 it is seen that inlet air is drawn from a separate air chamber into which filtered air is admitted from the outside. The heated exhaust air is either discharged again into the outside air from the air-sealed transmitter vault or wholly or partially diverted into the station building for use for heating purposes as seasonal conditions may require. In the design of such a system the loss of pressure in air filters, louvres, etc must be taken into consideration in determining fan capacity. The fan system may be arranged for removal of heat developed in the other stages of the transmitter as well. As in water-cooled systems, flow relays must be installed to remove power in case of failure or reduction of cooling air flow.

Forced-air-cooled tubes make possible appreciable reductions in the first cost of transmitting equipment. Comparative estimates indicate the cost of a water-cooling system for a 50-kilowatt transmitter to be two or three times that of air-cooling equipment for the same installation using forced-air-cooled tubes. Cooling system operating power costs are materially reduced by the elimination of elaborate recirculation system requirements. Maintenance charges and program interruption losses are reduced to a minimum.

For copper, the material used in this case, $k = 9.7$ watts/deg C./inch /square inch

Thus we may write Equation (3a) as

$$P = \frac{hS\,(T - t_i)}{1 + 2.96\,(t_i + 273)\,\frac{hS}{Q} + \frac{l}{kA}\,hS} \text{ watts} \quad (5)$$

With the aid of this formula the proper radiator dimensions and the cooling performance characteristics of the tube as a function of rate of cooling air-flow Q in cubic feet per minute, maximum anode temperature T and power dissipation P may be completely determined.

The graph of Fig. 3 shows the permissible plate dissipation of a representative forced-air cooled tube, the F-124-A, as a function of inlet air temperature, t_i, for various rates of cooling air-flow, Q. Tests indicate close agreement with calculated data.

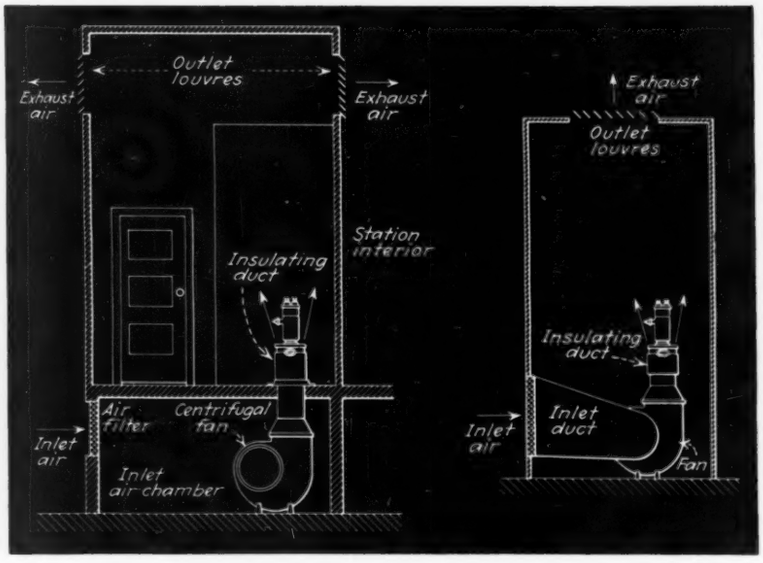


Fig. 5—Typical mechanical layouts of air-cooling systems: Left for a high power transmitter; right for low power

Mechanical Design

In order to make forced-air cooled tubes readily applicable for use in existing transmitters it was obviously advantageous to design the anode radiator for use with current types of standard water-cooled tubes. It was found possible to design a practical radiator assembly adequate to conduct away the required amount of heat from the previously water-colled anode without exceeding safe operating temperatures. While it has been found necessary to operate the anode at from two to three times its water-cooled temperature this has not resulted in a corresponding increase in temperature of metal-to-glass seals and glass envelope, in fact the air-flow serves effectively to cool these parts also. This is a very desirable feature, particularly for high frequency operation.

Radial Fin Construction

The construction adopted is to surround the anode with a heavy copper sleeve to the outside of which are brazed radial fins of a total surface area such as to satisfy Equation (5). The heat must be conducted with the minimum practical temperature drop between the inner anode and the cooling fins. This is accomplished by soldering the anode to the inner radiator sleeve wall with a thin film of low melting-point metal. In all brazing processes it is of the utmost importance that no blow-holes or low-conductivity spots be present, otherwise local over-heating and destruction of the tube will almost certainly occur.

Cooling-Air Supply

The power required to supply a given cooling-air flow through a radiator may be determined from the experimental fact that the pressure drop through a given radiator is approximately proportional to the rate of air flow squared, that is $p = KQ^2$. Since the air power in watts P_a required to force an air flow, Q cubic feet per minute, against a pressure p inches of water is 0.118 pQ, we may write

$$P_a = 0.118\,KQ^3 \quad (6)$$

where K is a constant for a given anode. Typical values of K are:

Type F-124-A ..... 0.4×10^{-6}
Type F-892-R ..... 1.4×10^{-6}

Adopting a fan efficiency, η_1, and a driving motor efficiency as at η_2, we can calculate the total cooling power consumption from $P_i = \frac{P_a}{\eta_1\,\eta_2}$. Suitable centrifugal fans operate at approximately 50 per cent efficiency. Typical asynchronous driving motors have efficiencies of 80 per cent. In the design of a given system allowance should be made for the additional pressure drop of ducts, elbows, etc, and correspondingly greater fan and driving motor capacity installed. An operating air flow somewhat in excess of that normally required is advisable to insure safe anode operating temperatures at any abnormally high ambient air temperature which may be experienced.

Figure 4 shows the cooling power required for various tubes as a function of anode dissipation. Figure 3 indicates that large anode dissipations may be maintained at high air velocities, but here rapidly increasing fan, motor, and operating power costs as well as noise constitute operating limitations. In order to obtain quiet operation streamline principles should be followed in construction of air ducts and other parts exposed to the air flow. For minimum noise a low-speed fan should be used.

The mechanical arrangement of fan and tube may be made extremely simple. A single blower may be used to supply one or several tubes. In the latter case the air ducts must be so arranged in multiple as to insure the proper air flow through each of the radiators under all conditions. In either case an insulating section of duct must be installed between the high potential anode and ground, and must be of such length as to preclude the possibility of flash-over and leakage currents under all conditions. Ceramic, plastic, or fabric ducts may serve this purpose. A

Capacitor Discharge Chart

By LOUIS HANOPOL
Tobe Deutschmann Corp.

DETERMINATION of the voltage characteristic of a capacitor in a state of charge or discharge through a resistor is one of the most common of electrical problems. The advent of the grid controlled vacuum tube has increased the utility of capacitance resistance networks as time controls. This function has been extended to timing relays, welders and relaxation oscillators. The fundamental circuits are given in the accompanying figure.

The accompanying chart offers a convenient method of carrying out computations of the solution of the differential equation of a capacitor shunted by a resistance.

This solution takes the form:

$$e/E = \epsilon^{-t/RC}$$

where E is the voltage of the capacitor at full charge,

e is the voltage of the capacitor at partial charge,

t is the elapsed time in seconds from the initiation of the discharge,

R is the resistance in ohms.

C is the capacity in farads.

The chart can be interpreted in terms of the voltage of the capacitor when it is being discharged thru a series resistor. The chart has as ordinates, e/E, the percentage of the voltage at full charge; and covers the range from 100 per cent to 0.1 per cent of maximum voltage. There are four overlapping curves which cover the time range from 0.01 to 100 seconds. All these curves satisfy the equation for RC equal to one. These together with the simple relation,

$$t_{\text{for any } RC} = t_{RC=1} \times RC$$

yield the solution for the large majority of problems.

Thus, to find the elapsed time interval from maximum voltage to any percentage of the maximum voltage, one merely reads from the chart the time interval for a given e/E and RC equal to one. This value of time is multiplied by the value of RC of the circuit being studied, and thus the latter's time constant is obtained.

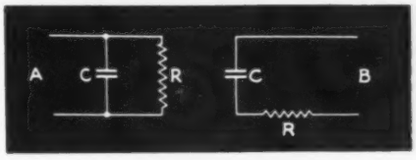
Again, if for any circuit, the time t and e/E are known, the chart can be read to give the time for a circuit with RC equal to one. For example, let the circuit be actuated at two points, E and $0.5E$. Let RC be equal to six.

$t_{RC=1} = 9.1$ seconds

$t = 9.1 \text{x} 6$ seconds $= 54.6$ seconds

If the capacitor is being charged, its voltage becomes $[E-(e/E)]$; ie, its voltage is $(1 - e/E)$ of the maximum. In the series case the voltage across the resistor is $[e/E] \times E$.

The applications of the chart are many, from the calculation of the size of a protective discharge resistor across a high voltage condenser, to relaxation and bypass computations. Most electronic circuits use



Fundamental capacitor discharge circuits

the RC nets to drive the vacuum tube whose output is to have two values separated by a given time interval, corresponding to that of the RC network. Control from the first vacuum tube may be extended to other tubes, transformers, and rectifiers as in welding systems. Relaxation oscillators are, from this point of view, timing systems in which the RC net biases the tube grid in the time interval $1/2 \times$ frequency, i.e., RC is such that the voltage change from zero to e, or e to maximum has an interval of $1/2 \times$ frequency, and the circuit oscillates at a frequency f.

Direct current filter systems can be treated by using the timing approach. Here, it is required that the ripple voltage across a resistor have a given value. For a simple capacity across a resistive load, the problem becomes that of maintaining e/E greater that some predetermined minimum percentage in the time interval $1/2 \times$ frequency. If e/E is never less than 99 per cent the ripple never exceeds one per cent.

Attacking bypass problems in the same manner, the percentage of alternating current in a shunt resistor is that which discharges into it in the time interval $1/2 \times$ frequency. Thus cathode bypassing can be treated in the method above.

The use of practical time control requires that some consideration be given non-idealized circuit components. Manufactured capacitors have losses inherent in the dielectric and insulation. These are interpreted in terms of an equivalent shunt resistance. Both the condenser and the resistor have variations in their characteristics with temperature and frequency and these cannot be neglected when their magnitude approaches the nominal ratings of the components.

Resistors of the metallized or carbon-bakelite type have been developed to a state where the residual inductance, and temperature variations are small. Large errors are not introduced from these sources until frequencies of 1000 cps and temperatures of 80° C. are reached.

The limitations of capacitors is most obvious from their characteristics. Frequency does not affect them to about 10 to 20 kc. The initial resistance, or shunt resistance of a capactor at 20° C. is 2 to 10 megohms per microfarad for electrolytic capacitors, 2000 to 4000 megohms per microfarad for paper halowax type capacitors and 8000 to 15000 megohms per microfarad for mineral oil impregnated condensors. The resistance gradient with temperature is steep and negative. If the shunt circuit resistor is not to be affected by the variation of the equivalent resistance the latter must be at least one hundred times the former. The value of the equivalent capacitor resistance at its lowest value because of temperature ambients limits the value of RC obtainable with any given type of condensor. Oil filled capacitors can be designed for RC as high as 50 to 100 for small temperature variations. Electrolytic and some vegetable and synthetic oil capacitors have positive capacitance coefficients with temperature at temperatures below 0° C.

TUBES AT WORK

Circuits for "writing" on a cathode-ray screen, introducing bass compensation in amplifiers, calibrating audio oscillators and timing photographic exposures automatically are presented this month

A Cathode-Ray Alphabet Machine

By ALBERT W. FRIEND
Cruft Laboratory, Harvard University

A new hobby with possible applications in the commercial world was developed at West Virginia University as a demonstration unit for a seminar talk. The idea was to show what could be done with a standard cathode ray oscilloscope and a few radio parts in producing, at will, various patterns on the screen. As a personal challenge the author decided to attempt the production of the entire alphabet.

The equipment used was developed during one day's work and included a standard DuMont Type 164 cathode ray oscilloscope, a pair of small radio receiver power transformers with some type 27 triodes connected as rectifiers, a DuMont Type 150 electronic switch, a special pulse generator utilizing the type 128A gaseous triode, a States Model R-13601 phase shifter, and about fifteen switches. The circuit diagram is shown in the accompanying figure.

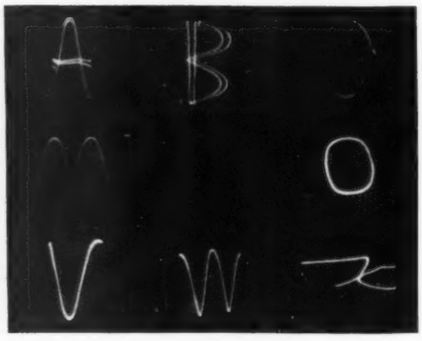
By judicious switching combinations and careful control of the sweep and phase adjustments every letter of the alphabet, used by English-speaking people was produced on the screen. Later all of the Arabic Numerals and many Greek letters were also formed. There is no doubt that all the Greek letters can be thus produced in a day or two of experimentation. The accompanying photographs show some of the resulting patterns photographed from the screen. Improvement can be made in the shapes of many letters and figures, but this attempt was merely for the purpose of illustrating what could be accomplished with a minimum of materials.

For convenience in reproduction of the apparatus, the switches have been numbered and a list of the switches closed to produce any desired pattern is given below. In some cases, phase shifts may be required to develop the listed pattern, and if the oscilloscope sweep circuit is used it must always be set to produce the desired trace.

It is hoped that subsequent developments will produce much better patterns and that some applications may be made to justify, in some way, the expended efforts.

The switching combinations required for forming the alphabet are as follows: "Int." refers to internal synchorization, "Ext." to external. The switch numbers and positions refer to the diagram in the figure. N denotes normal polarity of deflecting plates, R the reverse.

A—Int., SW., N, 2A, 3, 4B, 5B, 6
B—Int., SW., R, 1, 2B, 3, 4B, 5B, 6
C—Amp., R, 1, 2A, 3, 4A, 5A, 6, 8A, 9, 10, 11B, 12
D—Amp., R, 3, 4B, 5A, 6, 8A, 9, 10, 11B
E—Ext., SW., R, 7A, 11A
F—Int., SW., R, 4A, 5B, 6, 7A
G—Ext., Amp., R, 2A, 3, 4A, 5A, 7B, 8A, 9, 10, 11A
H—Int., SW., N, 2A, 3, 4B, 5B, 6, 12
I—R, V gain off.
J—Int., SW, N, 2A, 3, 4A or B, 5A, 6
K—Int., SW., R, 1, 2B, 3, 4B, 5B, 6
L—Amp., N, 4A, 5A, 7A, 12, Sn
M—Int., SW., N, 1, 2B, 3, 4B, 5A, 6
N—Int., SW., N, 1, 2B, 3, 4A, 5A, 6
O—Ext., Amp., N, 2A, 3, 4A, 5A, 8A, 9, 11A
P—Ext., SW, R, 2B, 3, 4B, 5B, 6, 8A, 9, 10, 11B
Q—Int., Amp., R, 1, 2A, 3, 4A, 5A, 7B, 8A, 9, 10, 11A
R—Ext., SW., R, 1, 2B, 3, 4B, 5B, 6
S—Ext., SW., R, 1, 2A, 3, 4B, 5A, 11A
or
Int., Amp., N, 1, 2A, 3, 4A, 5, 7B, 8B, 9, 10, 11B
T—Int., Amp., N, 4A, 5A, 7B, 9, 11B
U—Int., SW,., N, 1, 2B, 3, 4A, 5A
V—Ext., Amp., N, 1, 2B, 4A, 5A, 9, 11A
W—Ext., SW., N, 1, 2B, 3, 4A, 5A, 9, 11B
X—Ext., SW., N, 2A, 3, 4A, 5A
Y—Ext., SW., R, 2A, 3, 4B, 5A, 8A, 9, 11A
Z—Ext., SW, R, 2A, 3, 4A, 5A, 9, 11A, 13



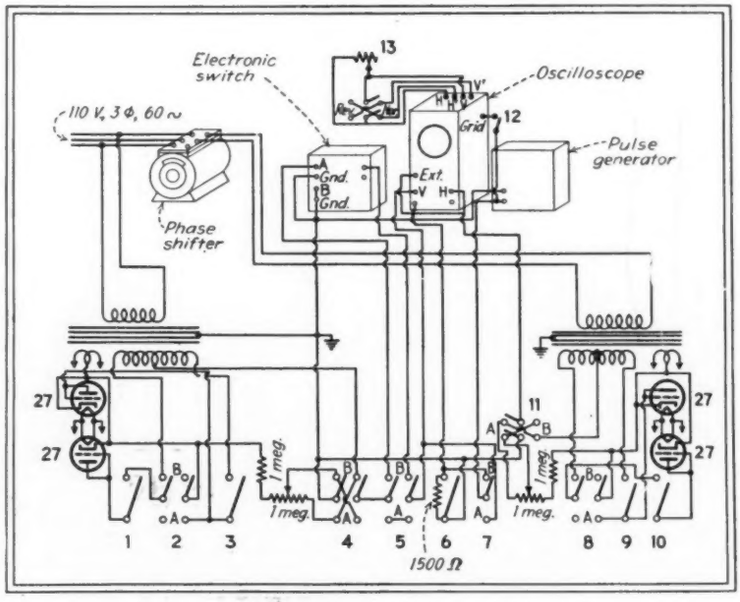
Examples of letters produced by the alphabet circuit

• • •

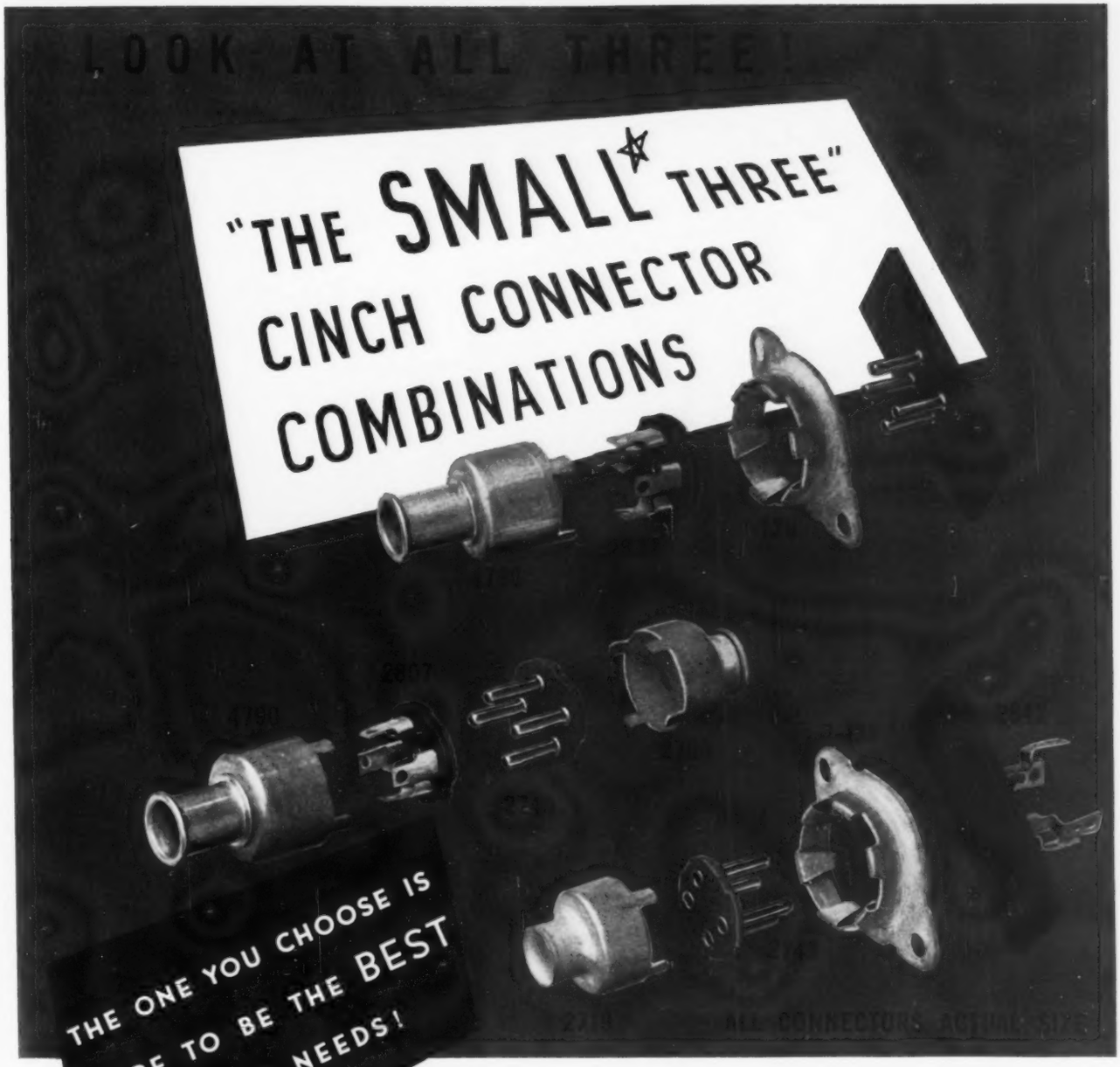
Elaborate Public Address System for LaGuardia Airport

ONE OF THE MOST ELABORATE announcing systems ever installed at an airport has recently been put in operation at LaGuardia Field, New York Municipal Airport, by the Western Electric Co. Field engineering and installation were carried out by the Langevin Co. The input consists of five microphones located at the ticket counters of the

(*Continued on page 44*)



Circuit diagram of the "alphabet machine." The switches are numbered to correspond with the text



★ Small space available for the radio set—smaller space in the set—developed the *smallest* connection parts; *shells*, *plugs*, sockets and grounding rings. Look at the three combinations shown here in actual size. They'll *fit* your needs.

Anticipating the need for space and time saving parts in the portable battery type sets, Cinch again is "First with the littlest". Already in use, these connection combinations are maintaining the reputation of "Cinch for satisfaction". Two, three or four prongs . . . adequate shell space . . . (note the two types of "handles") . . . best of materials and workmanship . . . here are the smallest parts for the end of battery cable lead for the latest and smallest of the compact radio sets. These connection combinations have proved highly efficient.

Cinch and Oak Radio Sockets are licensed under H. H. Eby socket patents.

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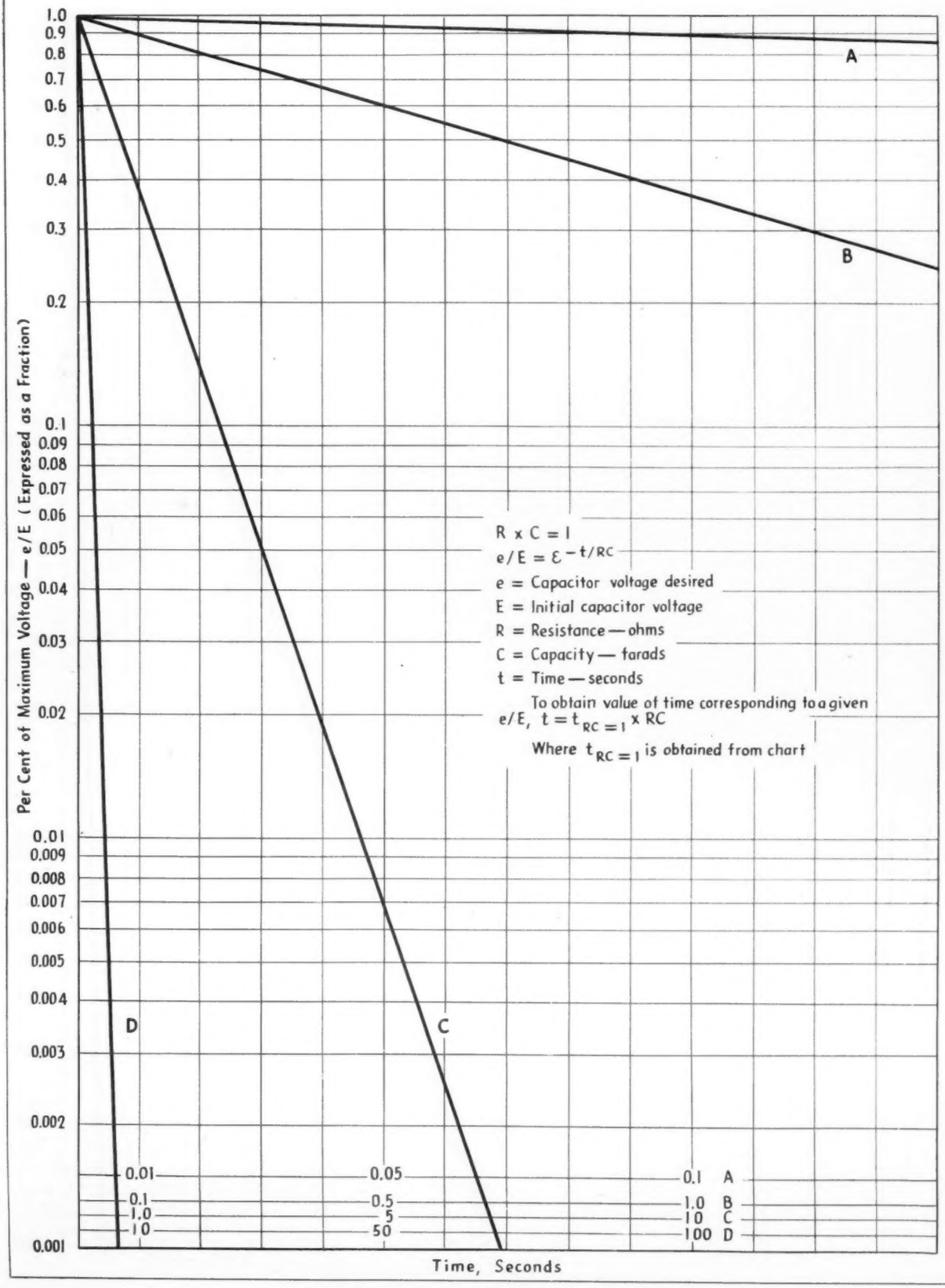
SUBSIDIARY OF UNITED CARR FASTENER CORP. CAMBRIDGE, MASS.

Capacitor Discharge Chart

By LOUIS HANOPOL, *Tobe Deutschmann Corp.*



UNITED

HIGH FREQUENCY AND GRID CONTROL POWER TUBES

AMATEUR — BROADCAST — COMMERCIAL — DIATHERMY — ELECTRONICS — FILM-SOUND . . . .

and so on through the alphabet of transmitting tube applications, UNITED enjoys the favor of professional users.

For instance type BW-11 (834) above shown, is purchased in large quantities under contract with us by the U. S. Civil Aeronautics Authority for airway marker and beacon transmitters.

Leading broadcasting stations equip a generous number of their sockets with preferred types of UNITED triodes and rectifiers.

The medical profession with radio healing equipment, motion picture theatres, and the nation's gigantic industries come to UNITED ELECTRONICS COMPANY for power tubes. There are 50 types to select from, and your inquiries are cordially invited.

UNITED ELECTRONICS COMPANY

42 Spring Street Cable "UNELCO" Newark, N. J.

four airlines and at the information desk in the main rotunda. Each microphone is of the "press-to-talk" type, using interlocked relays which make the entire loudspeaker system available to but one microphone at a time. A total of 85 loudspeakers are placed at various points on the administration building and on the loading platform. Additional microphones are also available at nine gates along the loading platform and may be used for general announcement or to call taxis and porters. One of the features of the installation is the 360-degree coverage provided by the several loudspeakers on the loading platform, which are so arranged that the output of one blends naturally with the others. In the rotunda of the Administration Building three "cobra" speakers are mounted in the dome. Fifty-two additional loudspeakers are also placed behind grilles in the various public rooms of the Administration Building. Seven complete amplifiers are used to serve the installation.

• • •

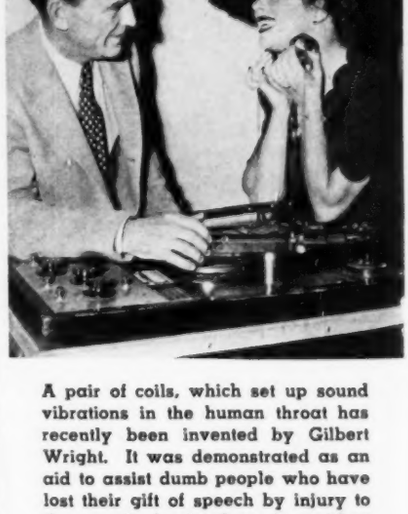
Bass Compensation by Screen-grid Injection

By L. M. BARCUS

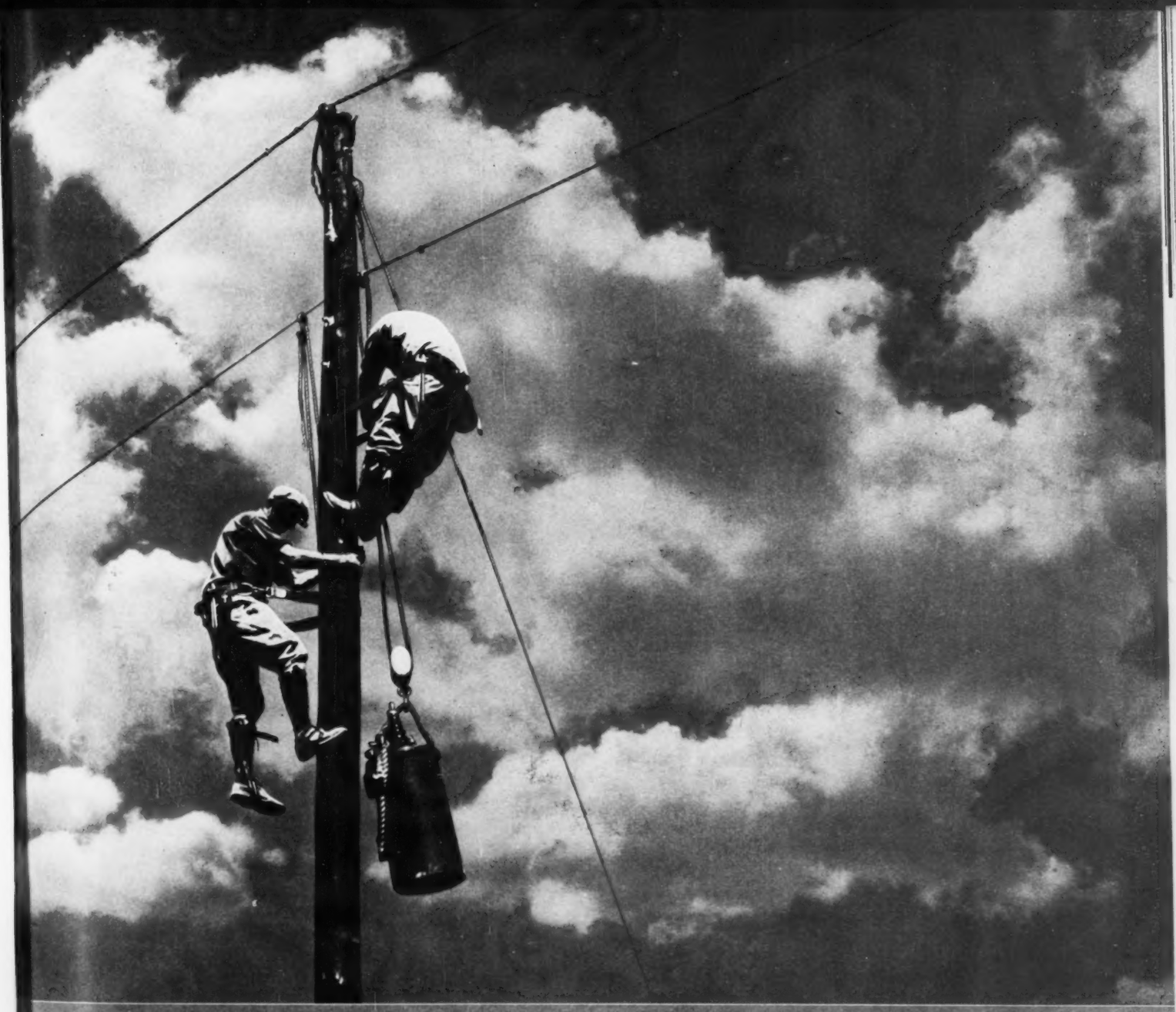
AMONG THE FAULTS to be avoided in applying bass compensation is the very common one of boomy speech reproduction. This means that practically

• • •

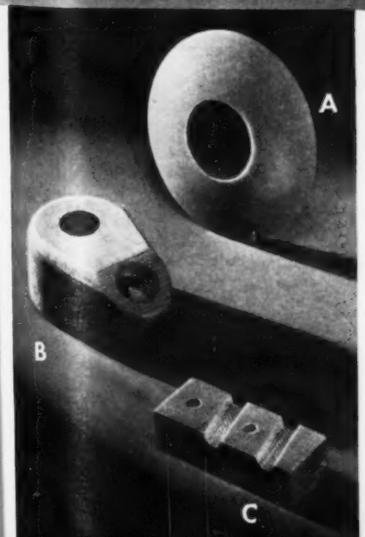
DEMONSTRATING SPEAKING AID



A pair of coils, which set up sound vibrations in the human throat has recently been invented by Gilbert Wright. It was demonstrated as an aid to assist dumb people who have lost their gift of speech by injury to the vocal chords through accident or disease. The instrument, invented by the son of the novelist Harold Bell Wright, is being demonstrated to Irene Rich. The device will not assist those who have never heard the human voice



Insulation Makes Electricity Usable



A—Washer, molded and turned.
B—Sawed, milled, drilled, counterbored, and tapped insulator.
C—Sawed, milled, and drilled in-

THE pole-top transformer that steps down voltages to household proportions is a familiar illustration of Synthane's value as a multi-purpose material. Synthane Bakelite-laminated, because of its combined electrical and machining properties, is used for insulating transformers, relays, power switches, bus-bars, and many power generating, distributing, and consuming devices from turbo-generators to kitchen clocks.

But Synthane combines many more properties. It is a dense, hard, uniform technical plastic, light in weight (half the weight of aluminum), structurally strong, and resistant to solvents, gases, petroleum products, water, and many acids and salts. And, it is easy to machine. You can machine it yourself or we'll machine it for you as we did for the three manufacturers whose products are pictured at the left.

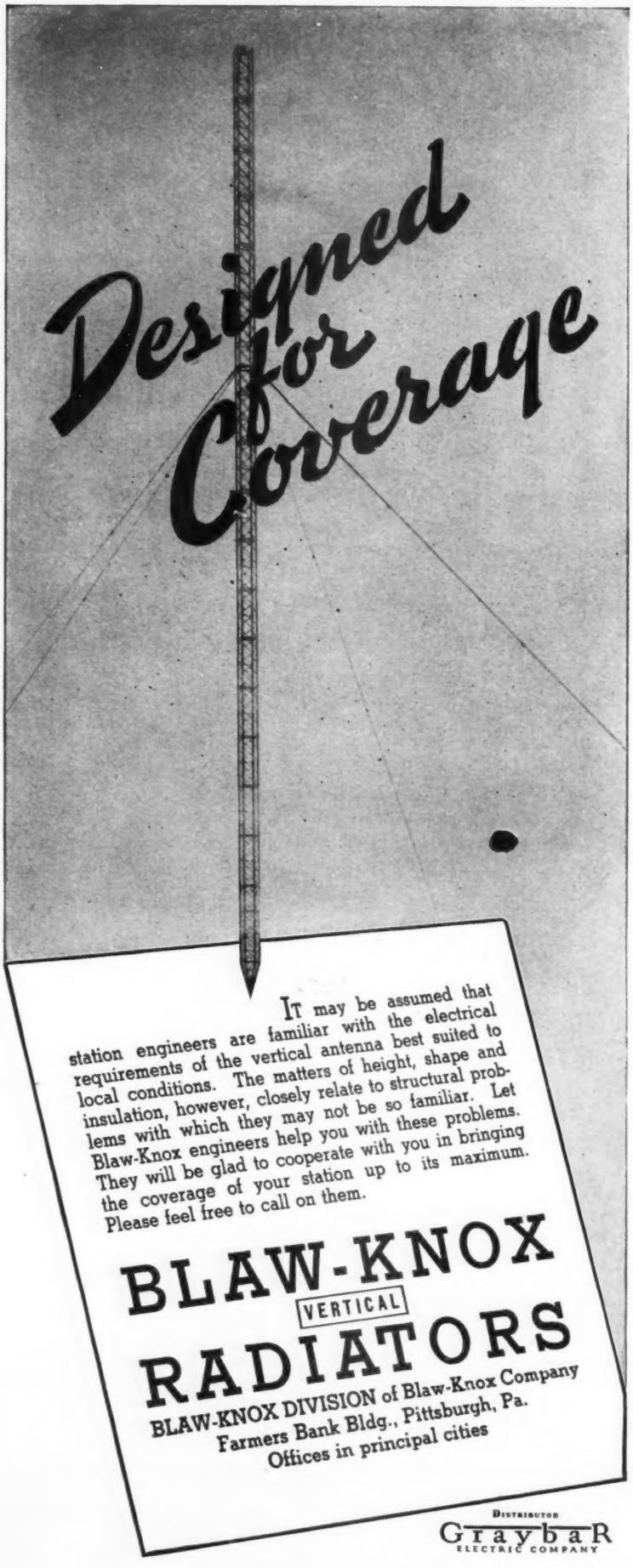
This wide choice of properties simplifies your approach to new applications, may enable you to improve the performance, salability and appearance of older products or equipment—or lower manufacturing costs.

If you have a hunch Synthane can help you, let's put our heads together on your job . . . today.
SYNTHANE CORPORATION, OAKS, PENNSYLVANIA

SYNTHANE
Bakelite—laminated

TECHNICAL PLASTICS

SHEETS • RODS • TUBES • FABRICATED PARTS • SILENT STABILIZED GEAR MATERIAL


Designed for Coverage
It may be assumed that station engineers are familiar with the electrical requirements of the vertical antenna best suited to local conditions. The matters of height, shape and insulation, however, closely relate to structural problems with which they may not be so familiar. Let Blaw-Knox engineers help you with these problems. They will be glad to cooperate with you in bringing the coverage of your station up to its maximum. Please feel free to call on them.
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VERTICAL
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Farmers Bank Bldg., Pittsburgh, Pa.
Offices in principal cities
Distributor
GraybaR
ELECTRIC COMPANY

all of the bass rise must be below the normally effective voice frequencies. It has been determined, moreover, that in order to achieve satisfactory richness of bass, the gain at 75 cps had to be somewhere in the order to 25 db. Since the rise had already been determined to lie below 150 cps to avoid conflicting noticeably with the male voice, this means the booster curve must be attenuated at the rate of 25 db per octave.

Unfortunately, a survey of existing methods of frequency correction uncovered no suitable method by which such an ideal curve might be attained. Unless some new circuit could be designed, it was granted that a compromise would have to be made between boomy speech and insufficient bass. However, the use of a multi-grid tube in the first audio stage seemed to offer one possibility. First of all, the screen itself could be a logical source of low frequencies. Already peaked in the required range, they would be given an initial gain and inverted in phase. In addition, the purely electronic coupling would make for stability even under high conditions of gain.

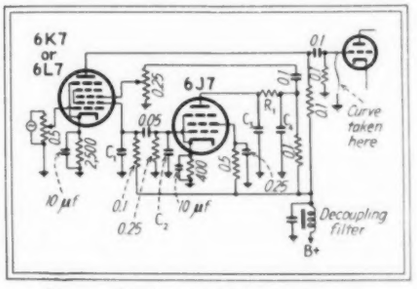

Fig. 1—Basic circuit for bass compensation using screen injection

The plan appeared feasible so an experimental model was designed. Ordinary by-pass filtering was used in the booster channel, for as yet no suitable method of obtaining the requisite attenuation had been advanced. However, the first response curve taken after placing the circuit in operation showed an amazingly sharp cut-off which could not reasonably be accounted for by the simple filtering em-

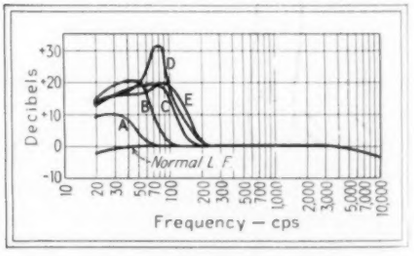

Fig. 2—Curves showing degrees of compensation possible with circuit of Fig. 1

ployed. Investigation revealed that the answer lay in an inherent property of the pentode itself, namely that the phase of the signal from the screen insisted on reversing with ascending frequency.

A number of representative curves are presented in Fig. 2, all taken on

"WE NOW HAVE MANY 450T's in service with nearly ten thousand hours of satisfactory service"

Says Mr. G. A. O'Reilly, ground station radio engineer for Transcontinental & Western Air, Inc.

TRANSCONTINENTAL & WESTERN AIR, INC.

TWA

10 RICHARDS ROAD
Kansas City, Mo.

March 7, 1940

Mr. J. A. McCullough
Eitel-McCullough, Inc.
San Bruno, California

Dear Mr. McCullough:

Our first Siebenthaler "individual radio frequency unit" transmitter was put in operation at the Kansas City TWA ground station eighteen months ago. Each radio frequency unit in the transmitter uses a pair of 450TL's in the output stage. The two tubes, which we operate at a plate potential of four thousand volts, deliver two and one-half kilowatts to the antenna with a surprising degree of ease.

During the early stages of the transmitter development, the use of inexpensive air-cooled triodes for power outputs of two or three kilowatts was the topic of considerable discussion. Various estimates of the tube life to be expected, most of which were not very encouraging, were made by interested persons. We were confident, however, on the basis of experience with your smaller tubes, that a pair of 450T's would handle this job. We now have many 450T's in service with nearly ten thousand hours of satisfactory operation.

450T

TWA opened its fifth station of this kind a few days ago and, in so doing, placed the seventieth 450T in daily operation. Installation work will begin immediately on five more stations, and we are now completing plans for additional installations which will bring the total up to fifteen. I believe that this equipment program in itself expresses our opinion of Eimac tubes.

Very truly yours,

G. A. O'Reilly

G. A. O'Reilly
Ground Station Radio Engineer

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Eimac TUBES

EITEL & McCULLOUGH, INC.
SAN BRUNO, CALIFORNIA

PASSENGERS ... RESS

...SO THEY'RE TUNING TO

Molded "Lucite"

ON RADIOS NOW!

MOLDED BY ELMER E. MILLS CORP., CHICAGO, ILLINOIS

AN interesting problem was this new type dial for Montgomery Ward's latest model "Airline."

The result is an interesting dial —with curved face "edge-lighted" to indicate wave bands.

According to Belmont Radio Corp., these two factors—*even light distribution* and *relatively low cost* —made obvious the selection of "Lucite" molding powder.

Flexibility of design is another point they mention. The four corners of the panel are molded as bosses for simplicity in mounting.

Also molded in are the depressed letters. These are later filled with paint. Thus a striking contrast is given by the "edge-lighted" letters in the clear, transparent dial face.

Nor were they forgetting the beautiful, soft lustre of "Lucite" methyl methacrylate resin itself —the crystal-clear plastic with so many, many uses.

You can depend on Du Pont Plastics for modern, functional applications. For more information write Du Pont, Plastics Department, Arlington, New Jersey.

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Meet **LUCITE**
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MOLDING POWDER

It's clear—with a beautiful soft lustre. In crystal form it is practically invisible, transmitting a high percentage of light. In translucent colors its clarity gives unusual effects.

It edge-lights—for illuminated dials and numerals (without glare). Automotive and radio uses are increasing constantly.

It's safe—because it's tough and practically unbreakable. Never any sharp, jagged edges or fragments.

It's strong—with tensile strength 7,000 to 10,000 lbs. per sq. in. and flexural strength 10,000 to 12,000 lbs. per sq. in.

It's weather resistant—stable in clarity, color. Three-year test shows no apparent change.

It's chemically resistant—to dilute alcohols, alkalis and mineral salt solutions.

It has low conduction properties—pleasant to touch and promising insulation applications.

It's light in weight—specific gravity 1.16 to 1.20.

It has high dielectric strength—

Dielectric constant: 60 cycles, 3.5 to 4.5
10^6 cycles, 2.5 to 3.0
Power factor: 60 cycles, 0.06 to 0.08
10^6 cycles, 0.01 to 0.03

It's easily molded—from highway reflectors to wet cell batteries, it's helped solve scores of difficult jobs.

THE LOW-DOWN ON ANODES

The amount of power a tube can handle depends largely on the ability of the Anode to dissipate the heat of operation.

Relative Heat Dissipating Value at 510°C.

Graphite	1.00	Tantalum	0.22
Tungsten	0.30	Nickel No. 1	0.025
Molybdenum	0.24	Nickel No. 2	0.001

Get tubes with Speer Graphite Anodes. List of tube manufacturers and booklet on request.

SPEER Carbon Company

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492

the basic circuit of Fig. 1. Not shown are other types which are sometimes useful in combating resonance effects, inasmuch as a dip occurs at the foot

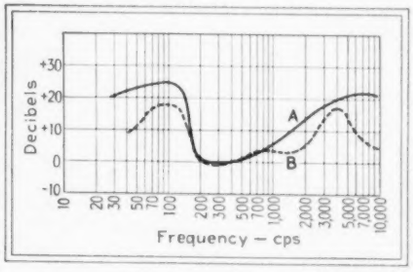

Fig. 3—Response curves of typical receiver using bass compensation system

of the bass rise. This is obtained by inserting a resistance in series with the input to the third grid. Ordinarily the dip occurs between the limits of 100 to 200 cps depending on design and is capable of control up to an attenuation of some 10 db.

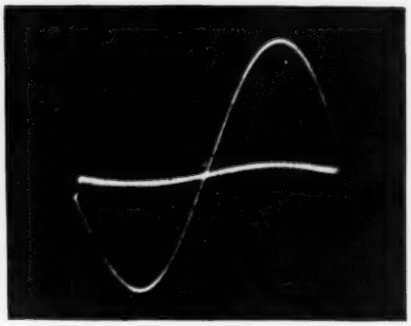

Fig. 4—Oscillogram showing low frequency output with and without compensation

Inasmuch as the "Syncrotronic" system herein described makes possible a very large amount of bass, enough in fact to compensate for all the losses generally encountered, it becomes feasible to make provisions for adequate high frequency response without experiencing the usual sense of harshness.

Experiments have shown that the Syncrotronic system of compensation makes possible several improvements over the usual methods. Among the most valuable in ordinary usage is the provision of audible and adequate true bass at extremely low levels of volume.

• • •

Calibration Circuit for Audio Oscillators

By T. J. Rehfisch and H. T. Bissmire
Murphy Radio, Ltd.

The ripple voltage in the output of the power supply unit is known to the engineer as an unwanted product and of interest only with regard to its suppression. This article describes a method for utilizing the "raw" component of the dc in making a-f measurements with the accuracy of the Greenwich Time Standard.

LENZ *Presents*
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DIAL LIGHT SOCKET

Voltage Breakdown between contacts—1200 Volts.
Voltage Breakdown to ground—5000 Volts.

Bakelite Shell is recessed for contacts, which cannot be pushed or pulled out of position.

Heavy wall Bakelite Shell.

Brackets on grounded type socket welded to shell preventing interference due to vibration.

Tensile strength of leads and connections far in excess of requirements.

Center contact mounted so that it cannot protrude from shell and short on chassis when lamp is removed.

Lug on contact fits in groove in shell so that contact cannot be turned or twisted when inserting lamp.

A variety of different mounting bracket styles available, suitable for practically any mounting.

• ***Complete Wire and Socket Assembly Accepted in Radio Receivers listed by Underwriters Laboratories.***

The superiority of the new Lenz Dial Light Socket, both electrically and mechanically is apparent with even the most casual inspection.

But even with its obvious superiority the use of the New Lenz Dial Light Socket will not add to the cost of your radio chassis. Samples will be gladly submitted upon receipt of specifications. Lenz Dial Light Sockets are made in both the two wire insulated type with bakelite shell and the single wire grounded type with metal shell.

LENZ

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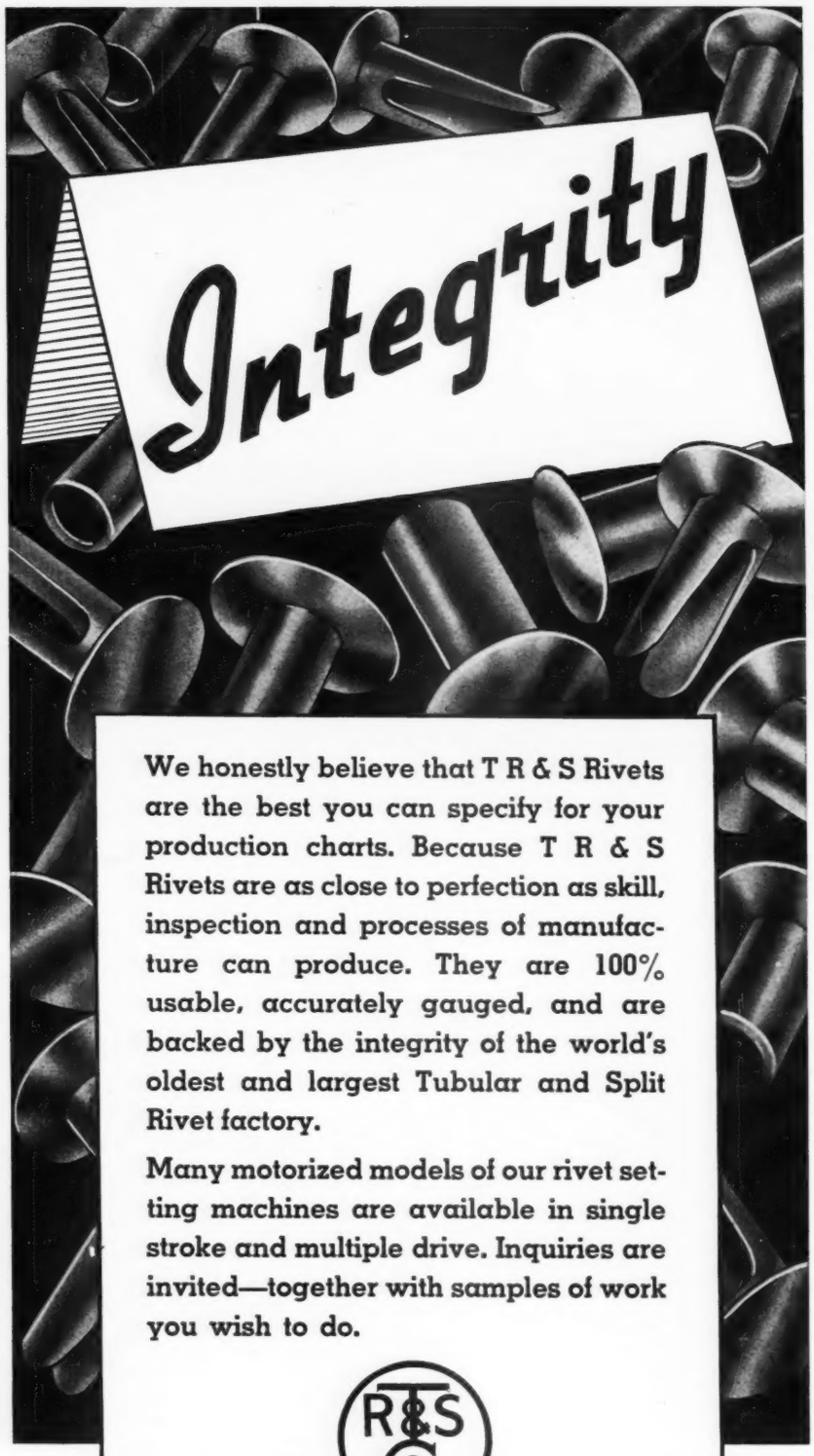

We honestly believe that T R & S Rivets are the best you can specify for your production charts. Because T R & S Rivets are as close to perfection as skill, inspection and processes of manufacture can produce. They are 100% usable, accurately gauged, and are backed by the integrity of the world's oldest and largest Tubular and Split Rivet factory.

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Audio oscillators of the beat-frequency type suffer from a certain amount of drift in their calibration. It is therefore necessary to provide means for rapid checking and resetting. A trimmer on the variable condenser is universally provided for resetting. Various methods have been used for checking, and these can be broadly divided into two classes: tuned reed and zero beat methods.

In the first group, an electrically-driven tuned reed is mounted so that it may be observed through the panel, the coil associated with the reed being excited by the output of the beat frequency oscillator. The main dial is set to the resonant frequency of the reed, and the trimmer is adjusted for maximum deflection of the reed.

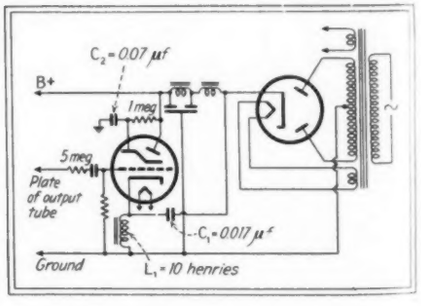
Zero beat methods fall into a number of categories. The most straightforward is the one in which the output of the bfo is set to be of zero frequency; the procedure is to turn the main dial to 0 and to adjust the trimmer until zero beat is observed on a meter in the output, e.g., an a-c voltmeter or a d-c milliameter in the anode of the mixing valve; the adjustment is considered completed when the meter needle executes only a single up and down movement in, say, 10 or more seconds.

Another scheme of zero beat adjustment is to compare the output with the frequency of the power lines or its second harmonic; detection may then be aural or by a meter fitted with a rectifier. Recently, the tendency has been to replace the meter by a visual tuning indicator for the sake of convenience, economy and electrical robustness. The movement of the meter needle is then replaced by the shutting and opening of the dark area of the "eye".

A Circuit Employing a Cathode Ray Indicator

It can be shown that for maximum accuracy, it is undesirable to check the calibration at the extreme end of the scale and to restrict the check to a single point. Moreover, it is inconvenient to be forced to switch or alter connections in order to effect the check. These objections are overcome by the circuit shown in the figure.

A conventional power pack, consisting of a full wave rectifier working in-



Circuit for calibrating audio oscillators

IRC Scores Again!

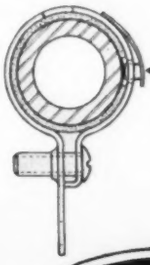
A New POSITIVE PRESSURE BAND FOR ADJUSTABLE RESISTORS

Heat-resistant, constant-pressure stainless steel spring spot-welded to band.

Positive pressure of contact button on wire never varies—never damages.

Thread on band—no nut required.

Flexible section permits easy bending for attaching bandtoresistor without disturbing radius.



Silver contact button eliminates oxidation and open circuits.

- *Prevents Oxidation and Corrosion at Point of Contact*
- *Eliminates Wire Damage and Breakage*
- *Cannot be Adjusted too Tightly*
- *Designed for High Temperatures*

It was a design engineer who classified adjustable resistors as a "necessary evil"—necessary because nothing can replace their convenience in adjusting resistance values to fit circuit requirements, evil because this adjusting so often results in damaged or broken windings. Furthermore, conventional-type bands with steel buttons provide opportunities for oxidation and corrosion.

The new IRC Positive Pressure Contact Band removes these troubles once and for all. No matter how much you tighten the band itself, the pressure of the silver contact button on the winding remains safe, constant and positive. No matter how often the bands are readjusted, there is no danger to the windings. The silver button prevents oxidation and corrosion, insuring good trouble-free contact at all times.

The band is cold-rolled steel heavily cadmium plated. The silver contract button is spot-welded to a heat-resistant stainless steel spring which assures constant pressure on the windings at all times. The units will not deteriorate under high operating temperatures or constant use. They are available in 9/16", 3/4" and 1 1/8" diameters for all IRC Cement Coated Adjustable Power Wire Wound Resistors from 25 to 200 watts inclusive.

FREE SAMPLE resistor with new band gladly supplied to manufacturers of original equipment or operating companies upon receipt of specifications. Write for IRC Bulletin No. IV describing all types, sizes and shapes of Power Wire Wound Resistors for every need.

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403 N. Broad Street, Philadelphia, Pa.

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Cement Coated

POWER WIRE WOUND RESISTORS

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That's the reward for using INSUROK electrical insulation — installed and forgotten. This precision plastic possesses qualities and characteristics that make it wholly dependable.

INSUROK

the Superior Precision Plastic

When Richardson set about to produce a plastic for the electrical industry, only one result was sought—the product must be the best that could be produced. How well INSUROK met this requirement is proved by its increasingly widespread use where difficult operating conditions are encountered, by its ability to deliver the utmost satisfaction, out of sight, and out of mind.

RICHARDSON TECHNICAL SERVICE. Many users of INSUROK find Richardson Technical Service indispensable. You are invited to avail yourself of these comprehensive facilities — without obligation, of course.

The RICHARDSON COMPANY

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to a 2-section filter with series choke input is employed to feed the instrument with rectified and smoothed dc. The "zero beat" detection device is a magic eye and the associated circuit shown in the figure; a Mazda ME41 was actually used. Its "leaky grid" is fed with 8 to 20 volts of audio from the plate of the output tube or the buffer-amplifier tube preceding the latter. The series circuit L_1-C_1 is fed from the cathode of the full wave rectifier; the wave form of the voltage at this point is well known; the a-c component consists of a fundamental of 120 cps (with 60-cps power; 100 cps with 60-cps power) and a series of harmonics, the amplitude of the harmonic being the smaller the higher the harmonic. The circuit L_1-C_1 is tuned so as to inject into the cathode of the indicator the frequency at which it is desired to check the oscillator—480 cps in the case shown. Since the audio input from the bfo is sufficient to drive the grid well into the non-linear region, the voltage at the plate-shield of the magic eye would contain components of the original frequencies injected as well as sum and difference components; the by-pass condenser C_2, however, acts as a short to ground on the shield for all frequencies exceeding a few cps. The procedure for setting the instrument is therefore as follows: with the dial set to 480 cps, the width of the dark area of the eye will narrow and widen slowly; the rate of this movement is reduced to zero by rotating the trimmer on the variable condenser.

Since the iron-cored coil L_1 has a large ohmic component, the resonance effect of the tuned circuit is not very sharp. Hence, a more feeble narrowing and widening of the dark area is observed at 360 and 600 cps and so are some negligible indications at other harmonics of 120 cps. However, there need be no fear of ambiguity owing to the differences in strength of indication; besides, it is unlikely that the trimmer will cover more than 120 cps at the low end of the scale. Incidentally the circuit also acts as an indicator for zero frequency output. Owing to the large resistance in the supply line to the grid of the eye, no feed back into the output of the bfo occurs and the eye can be left in circuit permanently.

By giving a suitable value to C_1 it is possible to select the fundamental or any of the first 10 or so harmonics of 120 cps as a standard of reference. Indeed, by providing for L_1 and C_1 to be interchanged easily, the circuit could be employed as a very accurate, if only subsidiary means, of primary calibration up to 2- or 3,000 cps.

Although these high harmonics of the ripple voltage are quite small at the rectifier cathode, the amplification of the series tuned circuit rises sufficiently to offset this effect rendering possible a clear "zero beat" indication.

Thanks are due to Murphy Radio, Ltd., for permission to publish this material which is in part based on work done in their laboratories.

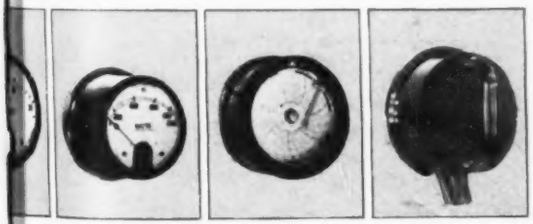
LECTRICAL VALUES

ed instruments take care of unusual pplications. All must conform to West-ghouse standards of accuracy, pre-sion and long life.

Ask any Westinghouse office for fur-er information and prices. Send for ur copy of Booklet 2219 — it contains luable information on the Westing-ouse system of electrical analysis. ddress Westinghouse Electric, East ittsburgh, Pa. Dept. 7-N.

OCKET INSTRUMENTS

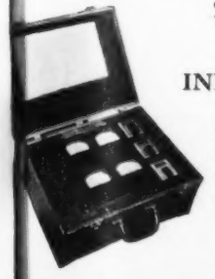
Economical Analysis



WATTMETERS Single-phase or polyphase, 115 volts—5, 10, and 20 amps capacity. Accuracy within 1%.

RECORDERS Circular chart voltmeters up to 750 volts and ammeters to 125-ampere capacity—1, 3, or 7-day chart. Accuracy within 3%.

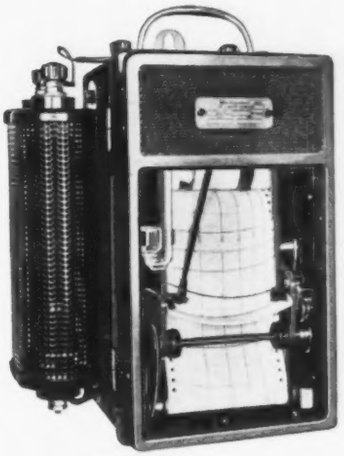
TEST JACK Convenient means of connecting any conventional instrument for test purposes.



INDUSTRIAL ANALYZERS

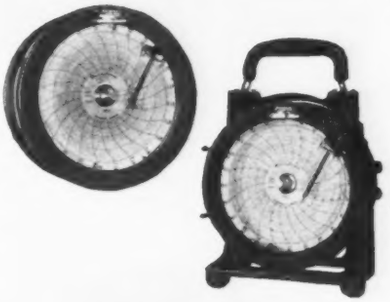
Applicable with test jack. Give complete test data without a single wiring change. Save time and expense.

RECORDING INSTRUMENTS



TYPE U

Voltmeters and ammeters, both portable and switchboard. Easy to install and operate, light in weight. Records continuous 8-day operation. Minimum friction. Accuracy within 3%. Permits assembling of data which otherwise would not be available without considerable expense.



TYPE A

Circular chart voltmeters and ammeters, switchboard or portable. For measuring load curves, station curves and for a wide range of industrial applications. Accuracy within 3%.

TYPE G-40

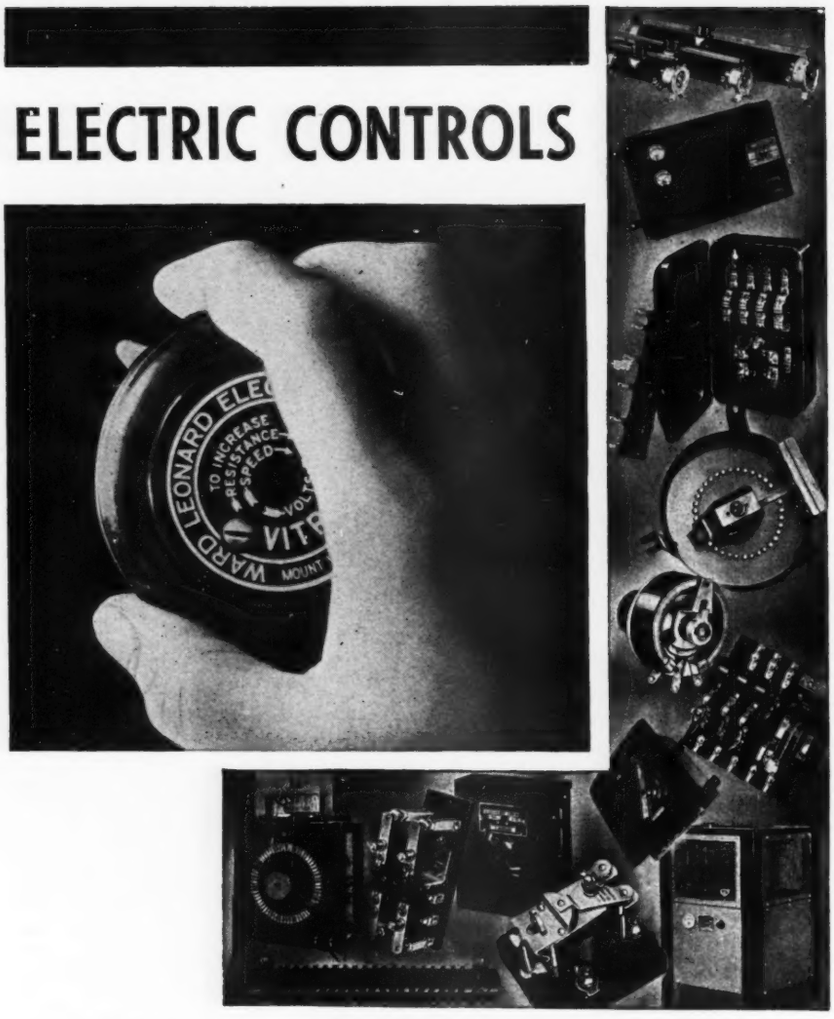
Direct-acting, strip-chart voltmeters, ammeters, wattmeters, and varmeters for 35, 17, 8, or 3-day records. Chart speeds — ¾, 1½, 3 and 6 inches per minute or inches per hour. Accuracy within 1%.

J-40230

Instruments

WESTINGHOUSE ELECTRIC

ELECTRIC CONTROLS



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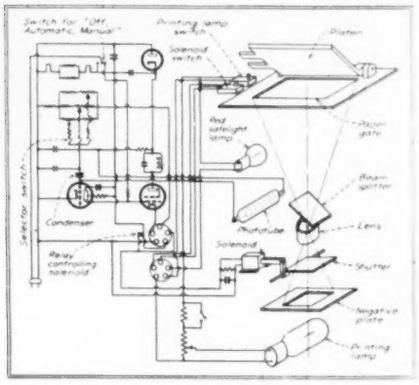
Phototube Controls Printing Exposures Automatically

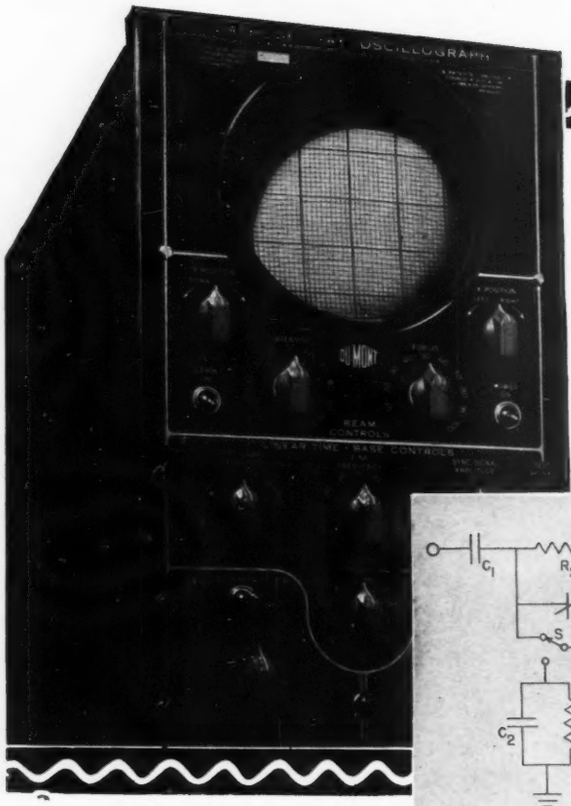
A COMMERCIAL FORM of automatic photographic printing control device has been made available through the Eastman Kodak Co., including phototube control circuits produced by the G-M Laboratories under Eastman's patents. The device is intended to make as nearly as automatic as possible the printing of standard size enlargements from small films. Reduction in waste of paper, more uniform prints and reduced training time for the operator are among the advantages which result.

Essentially the automatic printing control device is a photoelectric integrator. Charge applied to a capacitor in the grid circuit of a relay tube is allowed to leak off through a phototube, at a rate proportional to the amount of light hitting the phototube. This light is obtained, through a beam splitting device, from the light projected from the negative to the enlargement paper. When sufficient light has been received by the phototube to discharge the condenser, the relay tube operates the relay and terminates the exposure. The amount of light received depends on the density of the negative, and the effect is to obtain an almost uniform quantity of light falling on the enlargement paper, whether the negative is thin or dense.



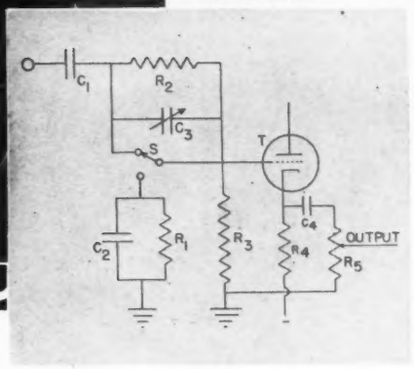
Electrical and mechanical arrangements of the photoelectric exposure control

The accompanying diagram shows the physical arrangement of the device. The projection lamp illuminates the negative and the image is projected upwards to the paper platen. The image is intercepted, however, by a magnetically controlled shutter and by a beam splitting mirror which transmits part of the light directly to the enlargement paper and the remainder of it to the phototube. The switching of the circuit is so arranged that when the top of the paper platen is closed, the magnetically-operated shutter is drawn back, and the exposure begins. Simultaneously the safe light is turned out and the phototube begins to discharge the condensers in the grid circuit of the relay tube. This initial tube is directly coupled to the final relay tube contain-



The DuMont Type 208 Cathode-Ray Oscillograph incorporating many new features and refinements, including nearly 15-inch time base, with 2½ times full-scale deflection. Extended sweep-frequency range—2 to 50,000 cycles. Amplifiers flat—2 to 100,000 sinusoidal cycles per second.

By direct coupling into the grid of a cathode-loaded tube, as shown below, and by subsequent attenuation in a low impedance circuit, all frequency discrimination of the input attenuator is avoided in this instrument.



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The use of a cathode-loaded impedance transformer is, in itself, nothing unusual. But in placing such a transformer on the input of a cathode-ray oscillograph, such as the Type 208 instrument, we were obliged to place the power supply potential with its ripple and surges on the input of an amplifier having a voltage gain of 2000 times, without having such distortions appear in the output, it was necessary to proportion circuit constants to permit a swing of 75 d.c. volts on the grid of a triode without affecting voltage linearity; it was essential that the d.c. component of the signal be eliminated during attenuation without affecting the low-frequency response of two sinusoidal cycles per second; and a resistance-capacitance compensated voltage-divider was to be provided for input signals as high as 250 r.m.s. volts without changing the input characteristics of the instrument.

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This and many other outstanding features of this new cathode-ray oscillograph are described in a new booklet just off the press. Send us your name and address, asking for Bulletin 48. We are pleased ourselves with this instrument and would like you to know more about it.

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ing the relay circuit which terminates the exposure by closing the shutter when sufficient light has been received by the phototube to discharge the condenser. A rectifier tube is also included for power supply.

The operator follows an extremely simple routine in using the printer. First he places the negative in the printing position and judges the contrast range so as to select the proper grade of printing paper for the negative (soft, medium or contrast type). A button corresponding with the grade of paper is then depressed in the control switch, the paper placed in position on the paper platen, and the platen cover pressed down. The automatic cycle of operation then occurs. When the exposure is completed the safe light again lights and the operator removes the paper which is then ready for development and fixing. Potentiometer adjustments are included in the circuit, so that the voltage to which the grid condenser is originally charged may be controlled in terms of the type of paper used, and also to compensate for minor variations between different emulsion numbers of the same grade of paper.

• • •

Tellurium-Vapor Lamp Produces Continuous Spectrum

A NEW TYPE OF VISIBLE light source has been developed in the research laboratories of the Westinghouse Lamp Division at Bloomfield, N. J., employing tellurium vapor as the illuminant. Tel-

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RADIO THERAPY AIDS PARALYSIS VICTIM

This child whose legs have been useless since birth is now beginning to walk without help as a result of the application of ultra-high-frequency radio therapy. He is a patient in the Camden Road Clinic in England where treatments are administered at low cost

First with Transformers for F-M

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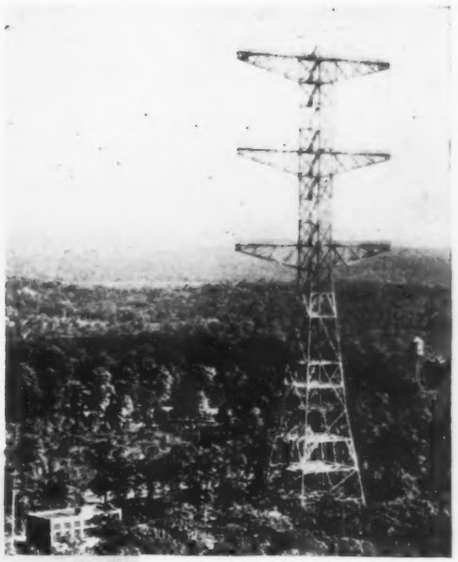

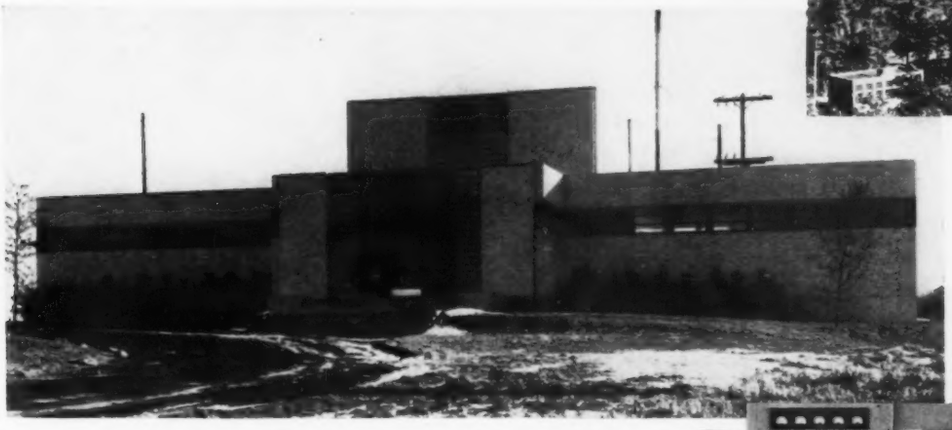

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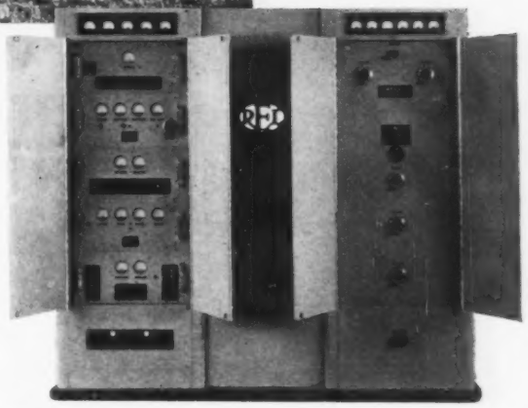

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Center—The new 50-Kw. F-M station WIXOJ (Yankee Network) at Paxton, Mass., to be visited by delegates of the I.R.E. convention, Boston, June 27-29.

Lower—A standard 5-Kw. R.E.L. F-M transmitter. AmerTran equipped.

AMERICAN TRANSFORMER CO.

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Manufactured Since 1901

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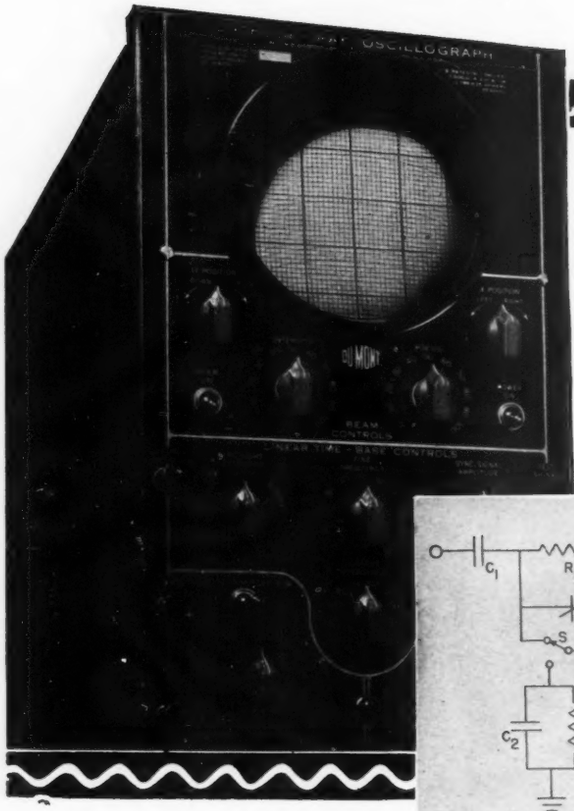

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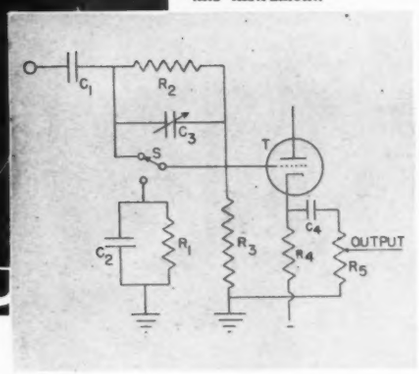

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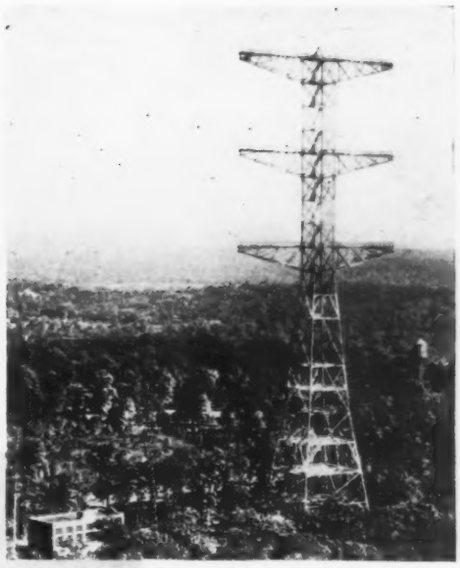

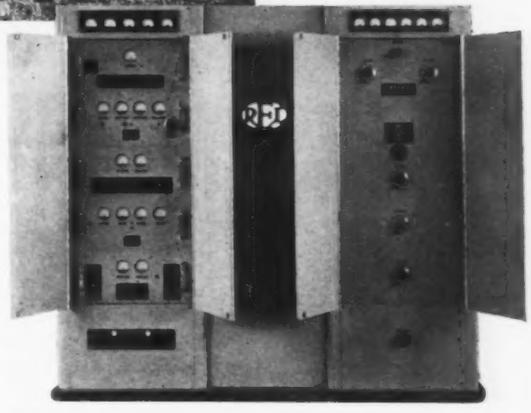

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Manufactured Since 1901

at Newark, N. J.

The Lingo Turnstile Antenna

has already been proven

ideal for FM operation!

Photo shows first turnstile antenna in commercial service, built by LINGO in 1937 for RCA for facsimile operation at Columbia-Presbyterian Medical Center, New York City.

Several LINGO turnstile antennas are in use by Maj. E. H. Armstrong at W2XMN, Alpine, N. J.; and by the Yankee Network.

Now, *already proven* by actual years of use by pioneers in Frequency Modulation, LINGO TURNSTILE ANTENNAS are recognized as ideal for FM transmission. These patented antennas provide the utmost in performance and efficiency. Our own pioneering in this new field of broadcasting enables us to furnish complete turnstiles comprising the essential tubular steel mounting pole, elements, insulators, wires, bands, etc. Specially designed for each application for installation on buildings or supporting towers.

WRITE FOR FURTHER INFORMATION

Our engineering staff will be pleased to assist you, without obligation, by planning the proper turnstile antenna for your particular building or supporting tower. Inquiries should indicate planned frequency, number of turnstile bays desired, location and height of building or supporting tower, etc.

JOHN E. LINGO & SON, INC.

Licensed Manufacturers of Patented Turnstile Antennas

DEPT. E-6 **CAMDEN, NEW JERSEY**

LINGO VERTICAL TUBULAR STEEL RADIATORS

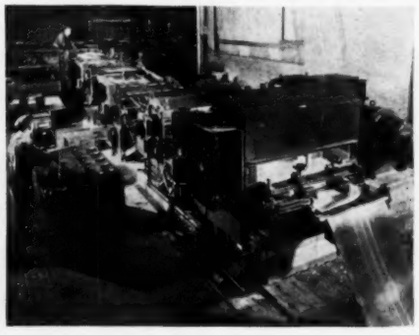
lurium, the 52nd element in the periodic table, has been found to produce a continuous visible spectrum of light which is almost exactly the same as that of direct sunlight. This particular type of radiation is produced only when the operating temperature of the vapor is low, at low pressure, and with low power input. As the temperature pressure and power input increase, the color changes increasingly in the direction of yellow, finally reaching a color somewhat similar to that of sodium vapor.

The efficiency of the vapor when used for white light radiation is low, only about one-third that of the usual 60-watt incandescent lamp. But at the maximum practical input the tellurium lamps are almost as efficient as mercury and sodium vapor lamps, which are very much more efficient than incandescent sources. The tellurium used must be highly purified, and the lamp must contain an inert gas (such as neon) to aid in starting the discharge. This inert gas is quickly absorbed by the metallic vapor so a gas reservoir must be attached to the lamp. Another requirement is that the lamp be operated on pure direct current. The vapors of zinc and cadmium have also been successfully used in lamps of this type. However, the spectral output of these latter lamps is confined to a few spectral lines. Light from cadmium consists principally of red, green and blue, while that from zinc is composed of red and blue only. The zinc and cadmium light lamps may be used in conjunction with mercury vapor discharge lamps to produce approximately white light. No immediate commercial applications are contemplated for the new lamps.

• • •

Phototube Inspects Steel Strips for Pinholes

A RECENT INSTALLATION of pinhole detector apparatus has been made by Westinghouse to allow continuous inspections of steel sheets moving up to 1,000 feet per minute. The device is intended to spot holes as small 1/100 inch in diameter and to mark the sheets opposite any holes which are so de-



Installation for continuous detection of pinholes in steel sheet

0.0025% FREQUENCY STABILITY OVER ROOM TEMPERATURE RANGE OF 32° TO 122°F

GENERAL ELECTRIC
FM
BROADCAST
TRANSMITTERS
ARMSTRONG SYSTEM

The complete G-E 1-kw FM transmitter; less than 10 square feet of floor space is required

Four Times Better Than F.C.C. Requirements!

. . . in a 5½-hour test over an ambient temperature range of 90° F. That's what actual measurements on a typical G-E frequency-modulation transmitter showed. And even better stability is obtained under normal conditions.

G.E. Does It Simply!

A single low-coefficient quartz crystal unit (temperature controlled) controls the frequency. Mean carrier frequency is electronically compared to a multiple of crystal frequency. Tendency to drift is instantaneously cancelled by automatic application of a corrective voltage of the proper magnitude to the reactance-tube modulator.
Correct carrier frequency is thus maintained by direct comparison to a precise crystal frequency.

Why the Simplified G-E Design?

Greater dependability; keeps you "on the air"—an important feature in commercial operation.
Amazing accessibility; *every part and wire easily reached without disassembly; all tubes instantly accessible by opening main access doors!*
Small tube-complement; only 31 tubes in entire 1-kw transmitter
Low tube cost
Single crystal control; *accurate; positive*
Easy to operate
Small floor-space requirement
Only simple shielding required, giving easy access to circuit components
Fewer parts; less space needed

Additional Performance Characteristics

(measured on typical production transmitter)

Audio-frequency response: Flat to within ±0.5 db, from 30 to 15,000 cycles.

Harmonic distortion:

30 cycles = 0.9 % RMS
100 cycles = 0.6 % RMS
1000 cycles = 0.55 % RMS
5000 cycles = 1.25 % RMS
7500 cycles = 1.5 % RMS

Carrier noise-level: FM noise down 65 db from modulation level at ±60 kc carrier-frequency deviation. (Down 70 db at ±100 kc deviation) A-M hum down 55 db. All values unweighted.

Linearity: Within ±0.1 db up to ±75 kc carrier frequency deviation.

Cross Modulation: 0.7% RMS at ±60 kc deviation with signal inputs of 400 and 700 cycles, and 4000 and 7000 cycles.

CALL or WRITE the nearest G-E sales office (there are 80 throughout the United States) for the whole story on how General Electric FM broadcast transmitters will give you more dependable performance at less cost. General Electric, Radio and Television Department, Schenectady, N. Y.

GENERAL ELECTRIC

160-2

High-Frequency radio coils manufactured by the F. W. Sickles Co., Springfield, Mass. Textolite fabricated tubing is used.

Coil Forms

AND TEXTOLITE MORE THAN MEET THE SPECIAL INSULATION REQUIREMENTS

For any electrical radio or electronic part that requires complete insulation you will find Textolite laminated an excellent material. Its many grades permit a wide selection—you can easily choose the right grade to do the best job for you.

And as for forms, Textolite is available in sheets, rods, tubes, and in fabricated parts no matter how simple or how intricate.

General Electric's newly published price list on Textolite is now available on request. We suggest that you write for your copy now. Address Section G-10, Plastics Department, General Electric Company, One Plastics Avenue, Pittsfield, Massachusetts.

General Electric has recently reorganized its fabricating facilities to assure you of quick and uninterrupted service on fabricated parts. To take advantage of this improved service send inquiries and requests for prices direct to:

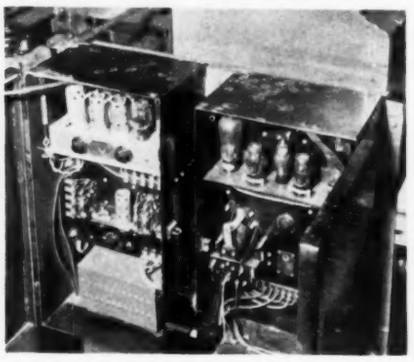
IN THE EAST—
Plastics Department, General Electric Co., 44 Cambridge St., Meriden, Conn.

IN THE WEST—
General Laminated Products, Inc., 3123-13 Carroll Ave., Chicago, Illinois.

GENERAL ELECTRIC

PD-108

tected. The application in this case is to a steel mill shearing line, for simplifying quality production. Two bright light sources are mounted in a cabinet over the flying strips. Underneath the sheets is the phototube housing which is mounted upon a separate foundation to avoid vibration. Any



The control equipment of the pinhole detector

hole in the steel permits the light to actuate the phototube, which in turn operates a relay controlling the marking device. This device scores the steel strip alongside the hole. After passing the pinhole detector, the strip is cut to exact lengths in a flying shear, after which the cut strip goes to the classifying equipment which discharges any defective sheets to a pit below the mill.

• • •

THE PROFILOMETER

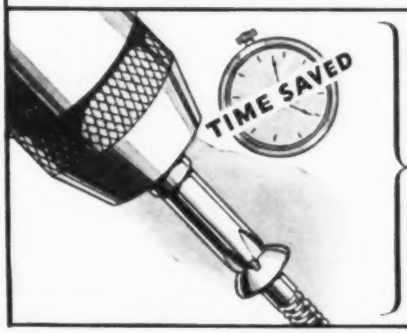
The Profilometer is an instrument used to measure the degree of smoothness of the surfaces of various automobile parts. The needle point, similar to a phonograph needle, is run over the surface under inspection. The voltage generated in the pickup is amplified and indicated on a meter so that variations of one-millionth of an inch are measurable

HOW TO KILL TIME ALL DAY AND DELIVER PRODUCTS FASTER

SLOTTED SCREWS ARE A SOURCE OF WASTED TIME AND EFFORT

GETTING SCREW STARTED — DRIVING WITH TWO HANDS — WHEN DRIVER SLIPS — PULLING OUT CROOKED SCREW

Why Fasten it the HARD Way, When it's QUICKER, CHEAPER and BETTER to Fasten With PHILLIPS Screws?



Quicker because Phillips Recessed Head Screws permit use of faster driving methods. Even when assembling easily-damaged, finished parts, power drivers can be used more often, since there's no danger of a slipping driver.

Cheaper because time is money and time-wasting operations—like boring pilot holes, withdrawing crooked or broken screws—are eliminated.

Better because assemblies are stronger, more attractive. Phillips Screws set up tight without split heads. Even inexperienced men do better with these easily-driven screws.

HERE'S WHY YOU SEE PHILLIPS SCREWS EVERYWHERE!

More and more manufacturers — large and small — are turning to this modern fastening method, to obtain time savings that average 50%. Orders are filled faster, money is saved, and the Phillips-fastened products have added sales appeal. Order from one of the manufacturers listed below.

PHILLIPS RECESSED HEAD SCREWS...

MACHINE SCREWS — SHEET METAL SCREWS — WOOD SCREWS — STOVE BOLTS

Speed Product Deliveries by Cutting Assembly Time

U. S. Patents on Product and Methods Nos. 2,046,343; 2,046,837; 2,046,839; 2,046,840; 2,082,085; 2,084,078; 2,084,079; 2,090,338. Other Domestic and Foreign Patents Allowed and Pending.

American Screw Co., Licensor, Providence, R.I.
Continental Screw Co., New Bedford, Mass.
Corbin Screw Corporation, New Britain, Conn.
The Lamson & Sessions Co., Cleveland, Ohio
National Screw & Mfg. Co., Cleveland, Ohio
Parker-Kalon Corporation, New York, N.Y.
Pheoll Manufacturing Company, Chicago, Illinois
Russell, Burdsall & Ward Bolt & Nut Co., Port Chester, N.Y.
Scovill Manufacturing Co., Waterbury, Conn.
Shakeproof Lock Washer Co., Chicago, Ill.

C·B·S ASKED FOR IT
PRESTO BUILT IT

A New, High Quality Transcription Playback That's Really Portable

● A short time ago, Columbia Broadcasting System engineers told us they were not satisfied with the portable transcription players then on the market. They told us what they wanted, a transcription player that would give perfect reproduction and yet be small and light enough for their personnel to handle conveniently.

We developed a new mounting which enables us to use a full size, magnetic pickup that tracks perfectly on a 16" transcription and at the same time keeps the size and weight of the unit extremely low. This pickup was combined with a new type of loudspeaker with matching amplifier and a Presto dual speed rim driven recording turntable... mounted in a carrying case measuring 15" x 15" x 19", weighing only 46 lbs.

Results were amazing. For practical purposes the reproduction was equal to high grade studio equipment. CBS immediately placed these playbacks in service. Agency executives and others who heard the new Presto playback ordered it for their own use. Now it's been added to the regular Presto line, designated as the Presto Model L Transcription Playback. List price is $250.00 FOB New York. Limited quantity ready for immediate delivery. Place your order today.

SEND FOR NEW PRESTO CATALOG!
Gives complete performance data on the entire Presto line of recording equipment and discs.

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242 West 55th Street, New York, N.Y.
World's Largest Manufacturers of Instantaneous Sound Recording Equipment

New Books

Introduction to Chemical Physics

By J. C. SLATER, *McGraw-Hill Book Company, 1939, pp. XIV and 521. International Series in Physics. Price $5.00.*

CHEMICAL PHYSICS, the author writes in the preface, is "an overlapping field in which both physicists and chemists should be trained. There seems to be no valid reason why their training in it should differ. This book is an attempt to incorporate some of the material of this common field in a unified presentation. . . . It is customary to write books either on thermodynamics or on statistical mechanics; this one combines both. It seems hardly necessary to apologize for this. Both have their places and both are necessary in a complete presentation of chemical physics." The last sentences of the book read, "To go further, one must make a great deal more study than we have of the principles of wave mechanics. A well-trained chemical physicist should be an expert in the quantum theory and wave mechanics, as well as in thermodynamics and statistical mechanics. Our effort in this book, however, has been to show that one can really get surprisingly far and understand nature surprisingly well with relatively elementary facts about the fine structure of matter and the principles governing its behavior."

The author has successfully accomplished his stated aims. Here is a book that will indeed surprise most serious students by the breadth and variety of theoretical science which it unfolds. It is no semi-popular discussion. Theoretical developments go back to fundamental postulates, and are carried forward to a point where deductions concerning advanced problems can be made. That so much ground can be covered with no more background than a knowledge of ordinary differential equations, elementary thermodynamics, and the rudiments of quantum mechanics will probably be a revelation to most readers, and is possible because of strategic omissions of much non-essential intermediate material. Steps which might be too complicated have been bridged by paragraphs of qualitative discussion. Care has been taken to point out specifically the points at which gaps in logical rigor occur, however, and while the reader must frequently accept statements upon faith, he seldom does so unconsciously. Due to the concentration of much material in a small space some of the author's statements may be intelligible only to students who already have some familiarity with the field. It is greatly to be regretted that no illustrative problems have been included as exercises. It seems safe to say, however, that the student who

They combine high intensity with sharp definition

Photograph of a high-speed transient taken with the 326C tube. Fundamental frequency of oscillation is 1 megacycle, with 3 megacycle component showing. Vertical line (right) represents a spot speed of 63 Km/sec. on screen of tube.

Photograph of three simultaneous electrical phenomena on a 330C screen.

CATHODE RAY TUBES by Western Electric

If you have time and frequency measurement problems, call on Western Electric Cathode Ray Tubes for help. They're designed and manufactured to meet your most exacting requirements.

The photographs above prove the ability of these tubes to combine high intensity and sharp definition. They also show the possibility of photographic records of various phenomena.

For use in studying two or three simultaneous phenomena, the Western Electric 330 series three trace tube permits on-the-spot comparison, showing phase relations and relative magnitudes.

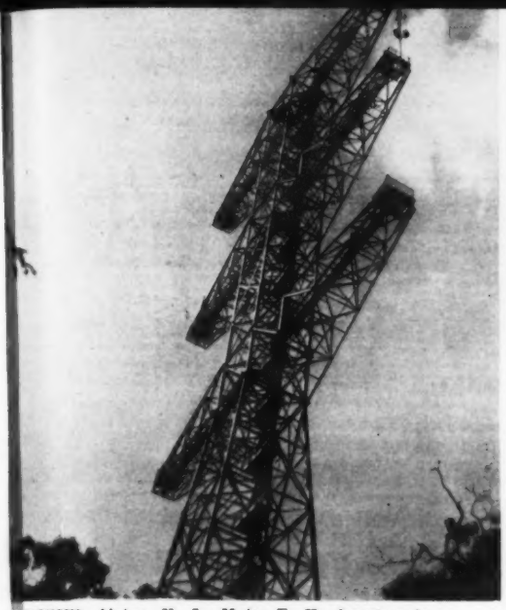
Get the full details from your distributor, listed below.

Distributed by Graybar Electric Company

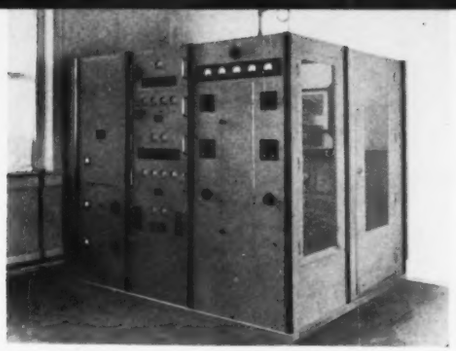
DISTRIBUTORS: *In U. S. A.:* **Graybar Electric Company, New York, N. Y.** *In Canada and Newfoundland:* **Northern Electric Company, Limited.** *In other countries:* **International Standard Electric Corp.**

GENERAL CHARACTERISTICS **SCREEN CHARACTERISTICS**

	325 TYPE	326 TYPE	330 TYPE	325A, 326A, 330A	325B, 326B, 330B	325C, 326C, 330C
Max. Length (in.)	16½	22	23-1/16	Green. Medium persistence, for visual observation and photography with green-sensitive film.	Blue-green. Long persistence, for observation and photography of non-recurrent and low frequency phenomena.	Blue. Highly actinic, for photography with blue-sensitive film.
Max. Screen Diam. (in.)	4⅝	7⅛	7⅛			
Heater Voltage	5.0 Volts	5.0 Volts	5.0 Volts			
Heater Current	0.55-Amps.	0.55 Amps.	1.65 Amps.			
Accelerating Voltage	1000-5000 Volts	1000-5000 Volts	1000-5000 Volts			
Deflection Sensitivity with 2000 volts Accelerating Potential	130 Volts/inch	80 Volts/inch	80 Volts/inch			



W2XMN—Alpine, N. J.—Major E. H. Armstrong's original 40 kw FM transmitter tower—equipment by R E L—in service since April 1938.



R E L FM equipment at W3XO—Washington, D. C.—Jansky and Bailey—in operation since August 1939.

R E L 3 kw FM transmitter at W9XAO (WTMJ) Milwaukee, Wisc.—The Journal Company—on the air since January 1940.

FREQUENCY MODULATION

(ARMSTRONG SYSTEM)

W1XOJ (Yankee Network) Paxton, Mass.—showing new 50 kw power amplifier room—on the air since May 1939 with 2 kw—since February 1940 with 50 kw—R E L equipped.

W8XAD (WHEC) Rochester, N. Y.—on the air since February 1940—equipped with R E L FM transmitter.

W2XOR (W O R) Bamberger Broadcasting Service, Newark, N. J.—Mutual's key station—on the air since March 1940—with R E L FM transmitter.

In collaboration with Major E. H. Armstrong, R E L built the first FM transmitters. As the pioneer manufacturer of FM equipment (since 1935)—R E L has built 95% of the FM stations now on the air.

All R E L FM transmitters employ the Armstrong phaseshift method of modulation with crystal control of the frequency—resulting in stability twice as great as required by regulations.

To assure yourself of the best in FM high fidelity and performance—we urge you to thoroughly investigate R E L—the pioneer manufacturer of a complete range of FM transmission units from 1 kw to 50 kw.

R E L is ready—complete manufacturing facilities—plus long engineering experience—enables us to immediately accept additional orders for FM transmitters—assuring prompt delivery — for fast installation and early operation.

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Cable "RADENGLABS"

LONG ISLAND CITY, N. Y.

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SEALDTITE

The Only
TUBULAR PAPER
CAPACITOR
which is

Reliable in Every Climate

We planned it that way! Life characteristics of low-cost tubulars are primarily dependent upon thoroughness of moisture exclusion. SOLAR Sealdtites are molded in hard wax: humidity is kept out, longevity is kept in. No other tubular has this construction. Put them on life test: your results will say STANDARDIZE ON SEALDTITES—FOR SAFETY!

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Quality Above All

masters this book will find himself intelligently oriented in the advanced literature of many fields of chemical physics. A great value of the book also comes from general comments by the author, whose original viewpoint permeates every chapter.

The book contains three sections. Part I, 111 pages, starts with a discussion of thermodynamics introducing the tables of Bridgman, from which all thermodynamic formulas involving first derivatives, over half a billion in number, can be systematically obtained. Four fundamental properties chosen for particular emphasis are internal energy, entropy, Gibbs free energy, and Helmholtz free energy. The remainder of the section is devoted to statistics, starting from a postulated definition of entropy and discussing Liouville's theorem, phase space in both classical and quantum theory, and deriving the partition function from the canonical assembly. A chapter on the Maxwell-Boltzmann distribution is followed by derivations of the Fermi-Dirac and Bose-Einstein distribution laws with computations of the above four fundamental thermodynamic functions for the former case.

Section II, entitled "Gases, Liquids, and Solids" contains 189 pages in which the fundamentals from the first section are used to interpret problems of mixtures of gases, imperfect gases, chemically reacting gases, equilibrium between solids, liquids and gases, the equation of state of solids, the specific heats of solids and compounds, the liquid state and fusion, phase equilibrium in binary systems, and order-disorder transitions. The approach is the same throughout; namely, to go as far as pure thermodynamics will allow in evaluating the behavior of the type of matter under consideration, then to carry the study further by using statistics. The role of the latter, made clear by repeated examples, is to evaluate constants in formulas for the thermodynamic functions already mentioned, and to provide information concerning subjects upon which thermodynamics throws no light; for example, specific heats and equations of state.

Part III (193 pages) deals with "Atoms, Molecules, and the Structure of Matter". Three chapters on radiation, the ionization and excitation of atoms, and the periodic table lead to the subject of interatomic forces. The rest of the section treats the properties and structure of ionic and molecular crystals: organic crystals and the silicates are the subjects of separate chapters. The book concludes with chapters on thermionic emission and the electronic structure of metals. There is a bibliography and an index.

Which features of the book will be most useful will depend upon the reader. The discussions of classical physical chemistry are lucid and illuminating while the more advanced sections contain much material which has not been readily accessible except in more advanced books and original papers. The chapters on lattice vibra-

THE CASE OF THE ENGINEER WHO

read only half an ad

"That's the sort of ceramic material I'd like to use," thought an engineer, wistfully reading about AlSiMag's low dielectric losses over the whole frequency band, and the excellent mechanical characteristics . . . the stability under difficult operating conditions of these ceramic materials.

Unfortunately, he stopped reading then and turned the page. Because his design specifications called for beauty—even to the insulating material. And so he never learned that engineers often specify AlSiMag as much for beauty as for quality. The fine workmanship and good looks of these ceramic materials add to the appearance of the smartest designs. Whatever your insulation problem, investigate AlSiMag. Bulletin No. 39 on request.

The TEST STORY of AlSiMag 197

Water Absorption
Extruded Material .10-.00%
Pressed Material .30-.00%

Heat Resistant
(Safe limit for constant temp.) 1000° C.

Tensile Strength
Unglazed 6500 lbs./in.²
Glazed 7500 lbs./in.²

Compressive Strength
Unglazed 75000 lbs./in.²
Glazed 80000 lbs./in.²

Modulus of Rupture
Unglazed 20000 lbs./in.²
Glazed 23000 lbs./in.²

Dielectric Strength
(step 60 cycles. Test disc ¼" thick) 180 volts per Mil

Volume of Resistivity
(at various Temperatures 220 Volts AC—60 cycles)
75° F. above 10^{8}*
1600° F. .6*
*meg-ohms per centimeter cube

AlSiMag
Trade Mark Reg. U. S. Pat. Off.

FROM CERAMIC HEADQUARTERS

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PLUG-IN
High Fidelity Audio Units

Uniform from 40 to 15,000 cycles, except items carrying D. C.

PLUG-IN High Fidelity Audio Units
(MAX. LEVEL 0 DB)
200 ohm balanced winding may be used for 250 ohms.

Type No.	Application	Pri. Imp.	Sec. Imp.	Net Price
P-1	Mike, pickup or line to 1 grid	50,200,500	50,000	$6.60
P-2	Mike, pickup or line to 2 grids	50,200,500	50,000	6.60
P-3	Dynamic mike to 1 grid	7.5/30	50,000	6.00
P-4	Single plate to 1 grid	8,000 to 15,000	60,000	5.40
P-5	Single plate to 1 grid, D. C. in Pri.	8,000 to 15,000	60,000	5.40
P-6	Single plate to 2 grids	8,000 to 15,000	95,000	6.00
P-7	Single plate to 2 grids, D. C. in Pri.	8,000 to 15,000	95,000	6.00
P-8	Single plate to line	8,000 to 15,000	50, 200, 500	6.60
P-9	Single plate to line, D. C. in Pri.	8,000 to 15,000	50, 200, 500	6.60
P-10	Push pull plates to line	8,000 to 15,000 each side	50, 200, 500	6.60
P-11	Crystal mike or pickup to line	50,000	50, 200, 500	6.60
P-12	Mixing and matching	50,200	50, 200, 500	6.00
P-13	Reactor, 200 Hys.—no D. C.; 50 Hys.—2 MA. D. C., 6,000 ohms			4.80
P-14	50:1 mike or line to 1 grid	200	½ megohm	6.60
P-15	10:1 single plate to 1 grid	8,000 to 15,000	1 megohm	6.60

UTC has been producing Plug-In transformers for audio service for the past three years. The new "P" series is the final culmination of this development. These units have identical characteristics to the popular UTC Ouncer* transformers, and **weigh only two ounces.** Units not carrying D.C. have high fidelity characteristics being uniform from 40 to 15,000 cycles. Items with D.C. in pri. and P-14 and P-15 are for voice frequencies from 150 to 4,000 cycles. They are of submersion proof design and fit standard octal sockets. The low weight and oversize pins used make it impossible to dislodge these units from their sockets, even when used upside down in portable equipment. Overall dimensions are 1⅛" diameter . . . height exclusive of terminals—1½".

*Our most copied line . . . yet never duplicated.

MICROPHONE CABLE TRANSFORMERS

The UTC cable transformers are designed to be inserted in the cable circuit, and are ruggedly constructed to withstand mechanical abuse. The cable connections (supplied less cable) are made through the spring strain relief to terminal boards inside the end caps. These units may be located any place on the cable within twenty-five feet of the amplifier. 1½" diameter . . . 2½" long.

Type MC-1 primary tapped 30/50 and 200/250 ohms, secondary to grid, standard fidelity ..... **Net $4.50**

Type MC-2 primary tapped 30/50 and 200/250 ohms, secondary to grid, high fidelity ..... **Net $6.00**

Type MC-3 crystal microphone to 50/200 ohm line ..... **Net $6.00**

UNITED TRANSFORMER CORP.
Write: ENGINEERING DIV. ★ 150 VARICK ST. ★ NEW YORK, N. Y.
EXPORT DIVISION: 100 VARICK STREET NEW YORK, N. Y. CABLES: "ARLAB"

tions in solids are particularly useful in this respect. A wide diversity of topics are treated, but in spite of this there is an impressive coherence to the work as a whole. One feels a pervading unity resulting from a deep knowledge and reintegration of the entire overlapping field to which the book is devoted. —DAVID B. LANGMUIR.

RCA Manufacturing Company

Lehrbuch der Hochfrequenz-Technik

By F. VILBIG, *Second Edition*

(Text book of Radio-frequency Engineering) 1019 pages—1359 illustrations. Published by Akademische Verlagsgesellshaft m.b.H., Leipzig. Price, 35.80 RM

Schrifttumsverzeichnis zum Lehrbuch der Hochfrequenz-Technik

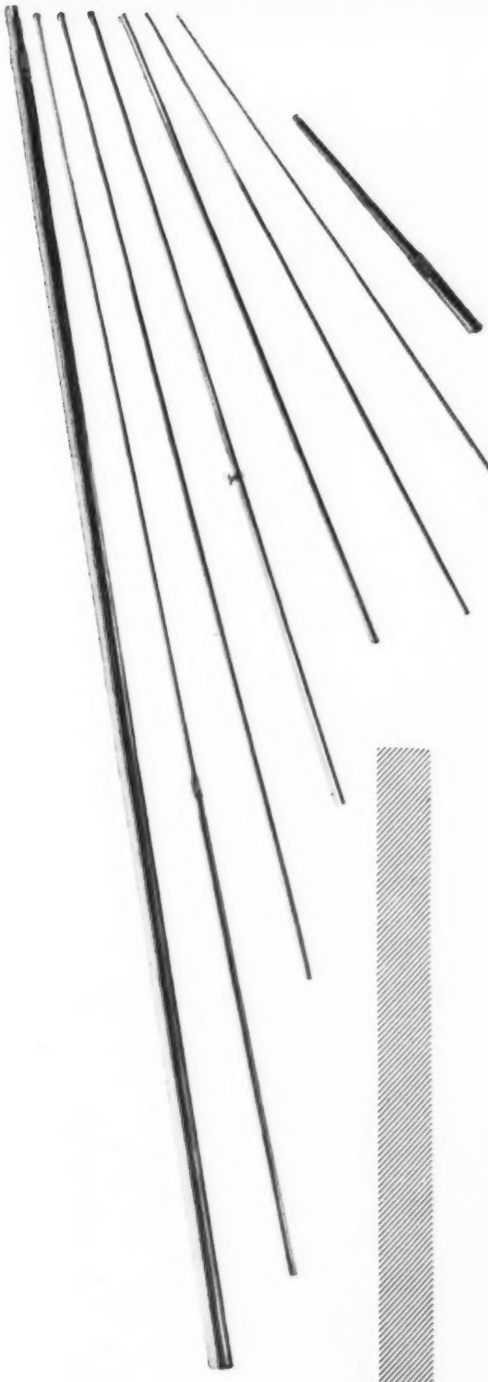
By F. VILBIG, *Second Edition*

(Bibliography to the Text book of Radio-frequency Engineering.) 172 pages. Published by Akademische Verlagsgesellschaft m.b.H., Leipzig. Price, 8 RM

THE EXCELLENT RECEPTION ACCORDED the first edition of this book since its appearance in 1937 has prompted the author to undertake this up-to-date second edition. In spite of the tremendous growth of all phases of radio-frequency engineering, his objective remains the same—namely, a comprehensive treatment of this entire field. The extensive revisions and additions have expanded the book to a point where it was deemed expedient to publish the expanded bibliography as a separately procurable volume.

Comprising 27 individual chapters, the first six are devoted to fundamentals, circuit analysis, including communication networks, wave propagation along lines and in free space, antennas and various types of disturbances. The next twelve chapters deal with tubes, amplifiers, oscillators, rectification, modulation, frequency transformation, etc., through to complete transmitting and receiving systems. The remainder of the book is devoted to miscellaneous topics such as multiplexing, wired-radio, channel width and utilization, facsimile and television. A special chapter deals with the heating and physiological effects of high frequency currents. At many requests a new chapter on accoustics, pertinent to the field of radio engineering, has been inserted. It was not possible, however, to give consideration to radio-frequency measurements technique.

In a comprehensive book of this character which attempts to cover such a tremendous field, it is evident that the author is constantly constrained by lack of space to a certain amount of "subject compression." Thus we find, for example, in the chapter on tubes



At extreme left is 25 ft. collapsible Marine Antenna. At extreme right is a working model to illustrate fittings. Others are for police car receiver and transmitter use, for portable transmitters and for passenger cars.

AERIAL PERFORMANCE

Corrosion resistance and high strength are the two most necessary qualities in modern tubular antennae, which must be *built to withstand tough conditions and give years of unfailing service.*

Up until three years ago, no one was making a really rustless and tarnish-proof antenna and until recently, a marine aerial over ten feet long was an unheard-of accomplishment. Superior Tube, in its new BRAWN* "Monel" aerials for automotive, marine, and experimental purposes has created exceptional standards of corrosion resistance and strength, to meet the strictest requirements for modern reception and transmission.

SUPERIOR BRAWN TUBING IS THE HEART OF THESE NEW AERIALS

"B" MONEL gives the following physicals:
Ultimate Strength —115,000-130,000 PSI
Elongation in 2" —4% to 8%
Rockwell Hardness—B 95-110

"K" MONEL, with approximately *25% higher* physicals, is also available but in the Seamless type only. Both "B" and "K" Monel are fully corrosion resistant, and can be produced by Superior in large quantities to close tolerances.

Superior introduced "Monel" for aerial application, and then developed the BRAWN type of tubing. Now, production is so large that prices are within the range of quantity buyers.

TUBING PRODUCED EXCLUSIVELY BY

SUPERIOR TUBE CO.

[THE BIG NAME IN SMALL TUBING]

NORRISTOWN, PENNSYLVANIA

* BRAWN — SUPERIOR TUBE CO

A Superior Trademarked Product

ANTENNAE MANUFACTURED AND DISTRIBUTED BY

PREMAX PRODUCTS
Niagara Falls, N. Y.
in Marine and Allied Fields

L. S. BRACH MFG. CORP.
Newark, N. J.
in The Automotive Field

ONLY RELAY USERS NEED TO READ THIS

Write today for Circular 1653Q.

It describes two amazing new Automatic Electric relays with qualities and features possessed by no other low-priced relay.

In three months, thousands have been purchased in place of "cheap" relays. (Cost is the same.) Experience of users reveals these benefits:

1. Reduced assembly costs (relays are preadjusted) 2. More reliable operation (contacts have heavy pressures — are "self-cleaning") 3. More positive action (armature restored by leaf-spring) 4. No over-heating (coil is "self-protecting").

Circular 1653Q explains these and many other advantages, and gives prices; also tells *why* you can buy this higher-quality relay at *no extra cost.* Write today.

AUTOMATIC ELECTRIC

Relay Makers Since 1898

1033 W. Van Buren Street Chicago

GOAT'S HISTORY OF SIGNIFICANT EVENTS—No. 9

IN '01 . . . .

The first metal-stamped automobile license plates appeared on public highways — meeting the obvious needs for identification which is now standard throughout the world. The Fred Goat Company, now 8 years old, was closely identified with the manufacture of precision machinery used in all branches of metal stamping.

TODAY...in 1940 —

Goat Radio Tube Parts, Inc. is closely identified with the most modern advances in radio set improvement. Modern improved Goat Tube Shields help make possible high fidelity reception, by providing maximum protection against outside interference, (2) simplify chassis design through their space-saving "form-fit" design, and (3) provide dependable long lasting service because of their sturdy construction.

Features:

1 Variety
2 Maximum Compactness
3 High Appearance Value
4 Tested Performance
5 Quick Service

Send for Bulletins

GOAT RADIO TUBE PARTS, Inc.
(A DIVISION OF THE FRED GOAT CO., EST. 1893)
314 DEAN STREET, BROOKLYN, N. Y.

that converters are dismissed in a few words, beam tubes are omitted, and in the discussion of frequency modulation no mention is made of the Armstrong system. The treatment of the ultra high frequencies in particular does not receive the emphasis it merits. On the other hand, the topics subject to the least amount of 'compression" are wave propagation, antennas, transmission lines, modulation and channel utilization. While liberal use is made of engineering mathematics, an excellent balance has been maintained between theoretical derivations and the physical processes involved and their application to practice. The majority of the 1359 illustrations are in the form of diagrams and graphs giving practical numerical data.

It is an interesting commentary on the tremendous growth of radio literature that the lapse of two years required the expansion of the bibliography from 102 pages in the first edition to 172 in the present edition. It is conveniently arranged into chapters corresponding to those of the book, each chapter being further divided by years from 1923 through 1938, with only outstanding papers previous to 1923 being given. In addition, several pages at the end are devoted to an excellent list of books, pamphlets, and other miscellaneous publications. It is indeed unfortunate that the author did not see fit to make the bibliography more international in scope. Although some of the important American papers are given, these comprise only a small percentage of the total, while British references are almost negligible. For example, in the chapter on negative feed-back, one finds that several important American papers, including the classical ones, are conspicuous by their absence. The bibliography, as an independent volume, suffers from the scarcity of American and British papers.

The textbook and its supplementary bibliography may be highly recommended as a text and as a valuable up-to-date reference book for the engineer and others.—HAROLD HEINS.

Look and Listen

BY M. B. SLEEPER,

The Norman W. Henley Publishing Co., New York, 1939, 96 pages, $1.00.

LOOK AND LISTEN IS devoted largely to detailed instructions for the construction and operation of a television receiver from the Andrea KT-E-5 television receiver kit. However, there are several chapters which give interesting stories on the various phases of television. The broad aspects of television are covered in the first chapter and the second chapter is devoted to a description of the television transmitter. There is also a chapter on television antennas. Even though a particular unit is discussed there is much valuable information given in this book.—C. W.

TUBES

Tubes registered with the R.M.A. Data Bureau during the month of April, 1940 and during the early part of 1938

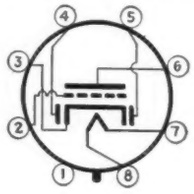
Tube Types Registered by R.M.A. Data Bureau During April 1940

Type 6SR7 (M)

Prototype 12SR7 (M)

DOUBLE diode, triode, heater type, (T-8) metal envelope, seated height 2 1/16 inches (max), 8-pin octal base.

E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v
E_c = —9 v
I_b = 9.5 ma
μ = 16
r_p = 8500 ohms
g_m = 1900 μmhos
C_{in} = 3.4 μμf
C_{out} = 2.8 μμf
C_{gp} = 2.0 μμf
Basing 8Q-1-0



Type 6AD7 G

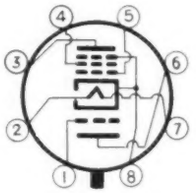
Prototype 6F6 (G)

TRIODE POWER amplifier pentode, heater type, (ST-14) glass envelope, seated height, 4 1/16 inches (max), 8-pin octal base.

E_h = 6.3 v
I_h = 0.85 amp

PENTODE
$E_b = E_{c2}$ = 250 v
E_c = —16.5 v
I_{bo} = 34 ma
I_{c2} = 6.5 ma
r_p = 80,000 ohms
g_m = 2500 μmhos
R_l = 7000 ohms
P_o = 3.2 watts (8%)

TRIODE
E_b = 250 v
E_c = —25 v
I_b = 4 ma
g_m = 325 μmhos
μ = 6
Basing 8AY-0-0



Type 6SD7 (GT)

R-F pentode, semi-remote cutoff, heater type, (T-9) glass envelope, seated height 2¾ inches (max), 8-pin metal sleeve octal base.

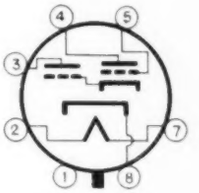
E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v
E_{c2} = 100 v
E_c = —2 v
I_b = 6 ma
I_{c2} = 1.9 ma
r_p = 1 megohm
g_m = 3600 μmhos
C_{in} = 9.0 μμf
C_{out} = 7.5 μμf
C_{gp} = 0.0035 μμf (max)
Basing 8N-1-5

Type 6AC6 (GT)

Prototype 6AC6 (G)

POWER amplifier (triple-twin), heater type, seated height 2¾ inches (max), 7-pin intermediate bakelite octal base.

E_h = 6.3 v
I_h = 1.1 amp
E_{bout} = 180 v (max)
E_{bin} = 180 v
E_c = 0 v
I_{bout} = 45 ma
I_{bin} = 7.0 ma
r_p = 18,000 ohms
μ = 54
g_m = 3000 μmhos
R_l = 3500 ohms
P_o = 3.6 watts (9%)
$e_{input\ for\ rated}$ P_o = 18 v
Basing 7W-0-0

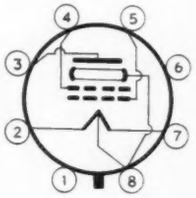


Type 3Q5G

Prototype 3Q5 (GT)

BEAM power amplifier, mid-tapped filament type, (T-9) glass envelope, seated 3 3/32 inches (max), small shell octal 7-pin base.

E_f = 2.8 v
I_f = 0.05 amp
E_b = 90 v
E_{c2} = 90 v
E_{c1} = —4.5 v
g_m = 2100 μmhos
r_p = 0.1 megohm
R_l = 8000 ohms
P_o = 0.27 watts (7½%)
Basing 7AP-0-0



Type 1LE3 (GL)

Prototype 1E4 (G)

TRIODE, filament type, (T-9) integral glass envelope-base, seated height 2¼ inches (max), 8-pin loktal base.

E_f = 1.4 v
I_f = 0.05 amp
E_b = 90 v
E_c = —3 v
I_b = 4.5 ma
r_p = 19,000 ohms
g_m = 760 μmhos
μ = 14.5
C_{in} = 1.7 μμf
C_{out} = 3.0 μμf
C_{gp} = 1.7 μμf
Basing 4AA-L-0

DISCOVERY OF MISSING ELEMENT REPORTED

The atom smashing scientists of the University of California have announced the discovery of what appears to be a new chemical element, the long sought Element 85. The new substance resulted from the bombardment of ordinary bismuth in the cyclotron with 32,000,000 volt particles of helium. The newly discovered substance is highly radioactive, disintegrates with an emission of x-rays and helium particles, and has an average life of about 7½ hours. Co-developers of the discovery are (left to right) Dr. Dale Corson, Kenneth R. MacKenzie, and Dr. Emilio Segre

PHOTOTUBE REFERENCE CHART

PHOTOTUBE REFERENCE CHART

With the recent introduction of new units, RCA rounds out the most complete, most diversified line of phototubes for all purposes. Small in size and inexpensive, each has been designed to meet the most exacting requirements of size, spectral response, sensitivity, stability and long life. Although the following chart gives essential characteristics of each type, engineering data bulletins on any number may also be had upon request to the RCA Commercial Engineering Section, Harrison, N. J.

NO.	NAME OR DESCRIPTION	PRINCIPAL USE		CATHODE		SENSITIVITY μAMP./LUMEN			SPECTRAL SENSITIVITY CURVE	GAS AMPLIFICATION FACTOR▲	DIRECT INTER-ELECTRODE CAPACITANCE μμf	MAX. AMBIENT TEMPERATURE °C	MAX. ANODE SUPPLY D-C OR PEAK A-C VOLTS	MAX. AONDE CURRENT● μAMP.	MIN. D-C LOAD RESISTANCE (MEGOHMS) FOR				
				SURFACE	WINDOW AREA SQ. IN.	0 CYCLES	1000* CYCLES	5000* CYCLES							UP TO 75-V SUPPLY	90-V SUPPLY		250-V SUPPLY	500-V SUPPLY
															BELOW 3.5 μAMP.	BELOW 2 μAMP.	ABOVE 2 μAMP.		
868	GAS	Sound Reproduction	D-1	S1	0.9	55	50	48	C-1	Not over 7	2.4	50	90	20	0	0.1	2.5	—	—
917	VACUUM with Anode Cap	Relays and Measurements	D-2	S2	0.9	20	20	20	C-2	—	2.0	50	500	30	0	0	0	1	10
918	GAS	Sound Reproduction	D-1	S2	0.9	110	102	93	C-2	Not over 10	2.4	50	90	20	0	1	4	—	—
919	VACUUM with Cathode Cap	Relays and Measurements	D-2	S2	0.9	20	20	20	C-2	—	2.0	50	500	30	0	0	0	1	10
920	TWIN (Gas Type)	Sound Reproduction	D-3	S1	0.3	75	70	63	C-1	Not over 10	1.5#	50	90	10	0	1.0	4	—	—
921	GAS (Cartridge Type)	Sound Reproduction	D-4	S2	0.4	100	97	90	C-2	Not over 10	1.1	50	90	20	0	1	4	—	—
922	VACUUM (Cartridge Type)	Relays and Measurements	D-4	S2	0.4	20	20	20	C-2	—	0.6	50	500	30	0	0	0	1	10
923	GAS	Sound Reproduction	D-5	S2	0.4	100	93	84	C-2	Not over 10	2.1	50	90	20	0	1	4	—	—
924	GAS (End Type)	Relays	D-6	S1	0.2	55	Less than 55	Less than 55	C-1	Not over 8.5	2.6	50	90	15	0	0.1	2.5	—	—
925	VACUUM	Relays	D-7	S1	0.4	15	15	15	C-1	—	1.0	50	250	20	0	0	0	1	—
926	VACUUM (Cartridge Type)	Colorimetry	D-4	S3	0.4	6.5	6.5	6.5	C-3	—	0.6	50	500	20	0	0	0	1	10
927	GAS	Sound Reproduction	D-8	S1	0.4	75	Less than 75	Less than 75	C-1	Not over 7	2.0	50	90	10	0	0.1	2.5	—	—
928	GAS (Non-Directional Type)	Relays	D-9	S1	0.7	65	Less than 65	Less than 65	C-1	Not over 10	2.8	100	90	15	0	1	4	—	—
929	VACUUM	Relays and Measurements	D-10	S4	0.6	45	45	45	C-4	—	2.5	100	250	20	0	0	0	1	—

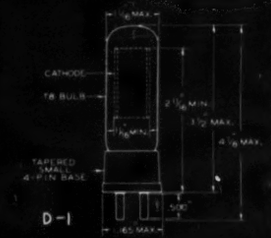
★ These sensitivity values are measured with a light input varied sinusoidally about a mean value from zero to a maximum of twice the mean. The sensitivity values shown are the ratio of the amplitude of variation in the current output to the amplitude of variation in the light input. The light source was a Mazda projection lamp operating at a filament color temperature of 2870°K. Sensitivity of the gas phototubes was measured with a 90-volt supply, a 1-megohm load, and a mean light input of 0.015 lumen. Sensitivity of the vacuum phototubes was measured with a 250-volt supply, a 1-megohm load, and a mean light input of 0.1 lumen.

▲ Ratio of sensitivity at maximum anode voltage to sensitivity at a voltage sufficiently low (approximately 25 volts) to eliminate gas ionization effects.

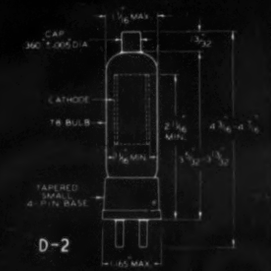
● On basis of the use of a sensitive cathode area ½" in diameter.

□ Values are for each unit.

Between cathode and anode of each unit. Capacitance between cathodes = 1.6 μμf, between anodes = 0.4 μμf.



D-1



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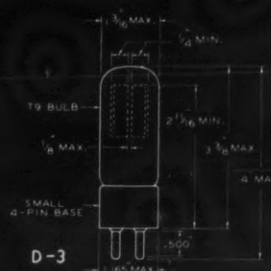

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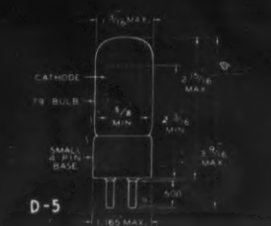

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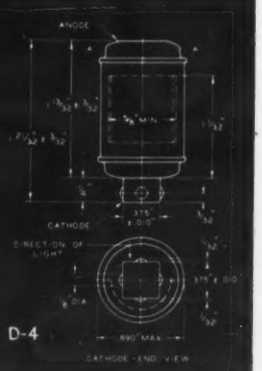
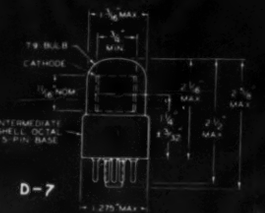
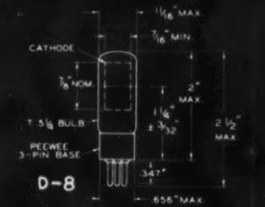


D-4

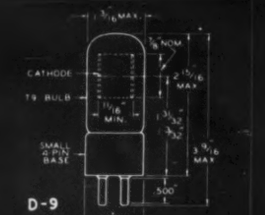
D-6



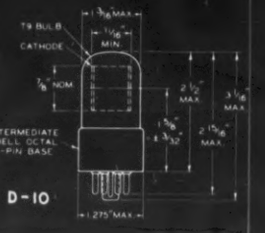
D-7



D-8

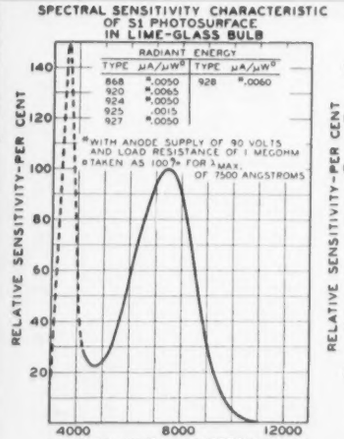


D-9

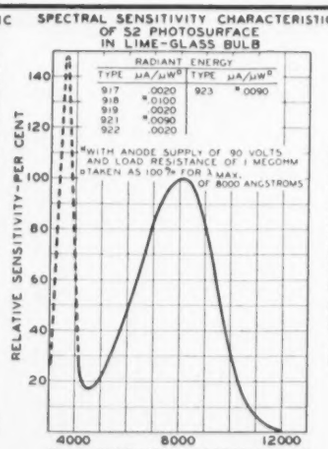


D-10

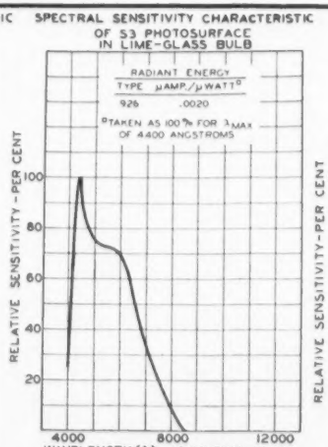
SPECTRAL SENSITIVITY CHARACTERISTIC OF S1 PHOTOSURFACE IN LIME-GLASS BULB


RADIANT ENERGY
TYPE μA/μW* TYPE μA/μW*
868 *.0050 928 *.0060
920 *.0065
924 *.0050
925 .0015
927 *.0050
*WITH ANODE SUPPLY OF 90 VOLTS AND LOAD RESISTANCE OF 1 MEGOHM
°TAKEN AS 100% FOR λ MAX. OF 7500 ANGSTROMS
RELATIVE SENSITIVITY-PER CENT
WAVELENGTH (λ)-ANGSTROM UNITS
C-1

SPECTRAL SENSITIVITY CHARACTERISTIC OF S2 PHOTOSURFACE IN LIME-GLASS BULB

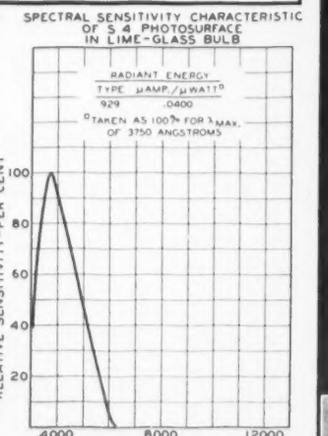

RADIANT ENERGY
TYPE μA/μW* TYPE μA/μW°
917 .0020 923 *.0090
918 *.0100
919 .0020
921 *.0090
922 .0020
*WITH ANODE SUPPLY OF 90 VOLTS AND LOAD RESISTANCE OF 1 MEGOHM
°TAKEN AS 100% FOR λ MAX. OF 8000 ANGSTROMS
RELATIVE SENSITIVITY-PER CENT
WAVELENGTH (λ)-ANGSTROM UNITS
C-2

SPECTRAL SENSITIVITY CHARACTERISTIC OF S3 PHOTOSURFACE IN LIME-GLASS BULB



C-3

SPECTRAL SENSITIVITY CHARACTERISTIC OF S4 PHOTOSURFACE IN LIME-GLASS BULB

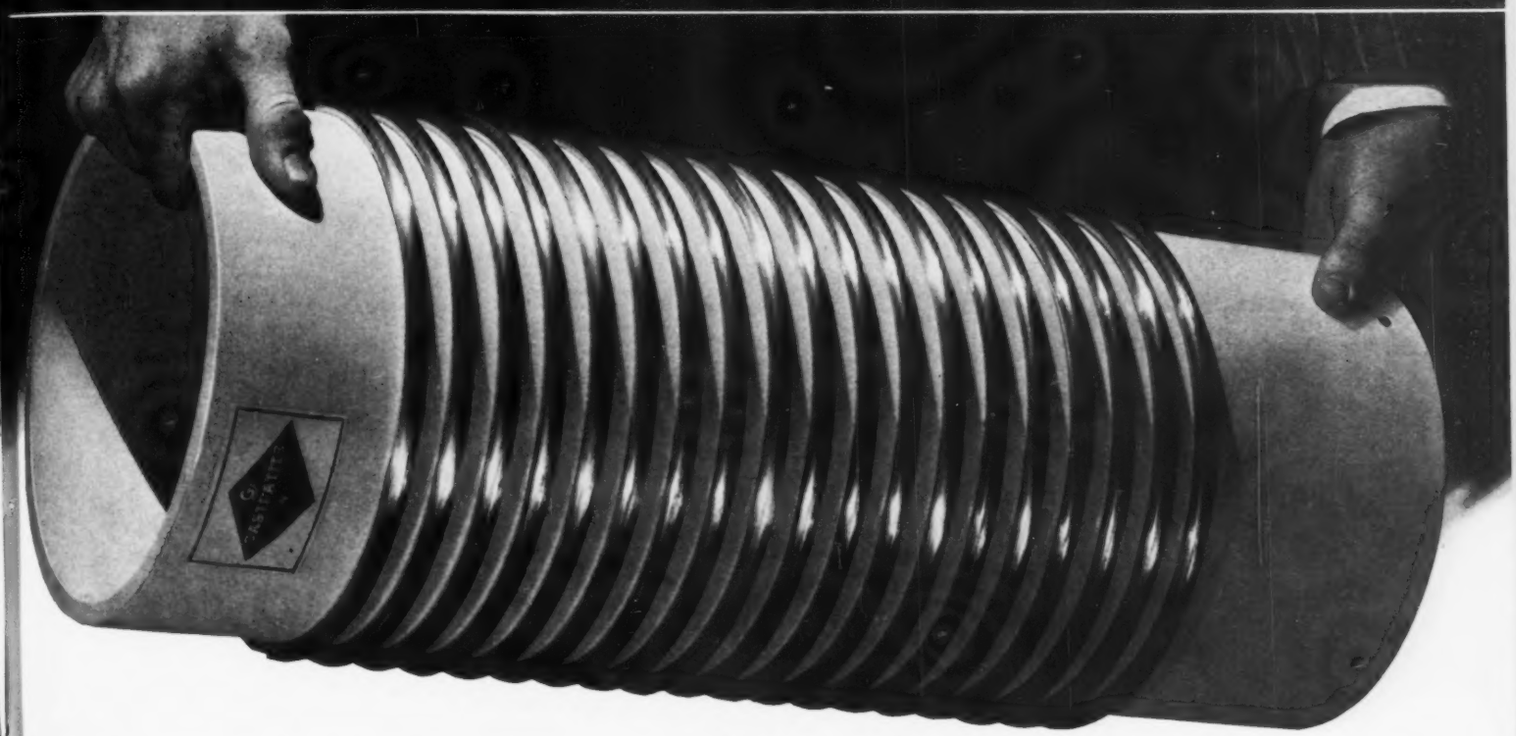


C-4

RCA MANUFACTURING COMPANY, INC.
CAMDEN, N. J.

A Service of the Radio Corporation of America

SYOUR SPECIAL PROBLEM
vloss high frequency insulation?



Whether your low-loss insulation problem has to do with AM, FM, or television . . . whether it is an electrical or a mechanical problem, or both . . . you will find an experienced engineering staff at General Ceramics to help you solve it.

In the General Ceramics catalog of Steatite and Ultra-Steatite, you will find a COMPLETE line of ceramic insulators for high frequency and ultra-high frequency requirements. You will find a large variety of standard items, and information about adequate facilities for developing and manufacturing special products to exacting specifications. You will find a dependable source of supply, backed by a reputation for cooperative service and equipped for quick deliveries.

Let us help you to solve your problems arising from the present-day and future use of higher and still higher frequencies.

GENERAL CERAMICS COMPANY, DEPT. E
RCA BUILDING, 30 ROCKEFELLER PLAZA, NEW YORK
SEE US AT THE I. R. E. CONVENTION . . . BOOTH 22

BIG shapes like this 9x25-inch Steatite coil form are one of our specialties. Some of the largest high frequency insulators ever manufactured in the United States have been produced by General Ceramics plants.

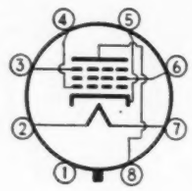
THIS CATALOG NO. 1000 WILL BE SENT TO YOU ON REQUEST

Steatite and Ultra-Steatite INSULATORS

Type 6SE7 (GT)

R-F pentode, sharp cutoff, heater type, (T-9) glass envelope seated height 2⅞ inches (max), 8-pin octal base, metal sleeve.

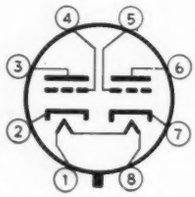
E_h = 6 v
I_h = 0.3 amp
E_b = 250 v
E_{c2} = 100 v
E_c = − 1.5 v
I_b = 4.5 ma
I_{c2} = 1.5 ma
r_p = 1.1 megohms
μ = 3750
g_m = 3400 μmhos
g_m = 5 μmhos @ −6 v
C_{in} = 6.0 μμf
C_{out} = 7.5 μμf
C_{gp} = 0.0035 μμf (max)
Basing 8N-1-5



Type 7N7 (GL)

DOUBLE triode, heater type, (T-9) integral glass envelope-base, seated height 2⅝ inches (max), 8-pin loktal base.

E_h = 7.0 v
I_h = 0.64 amp
Each Triode Section
E_b = 250 v
E_c = −8 v
I_b = 9 ma
r_p = 7700 ohms
g_m = 2600 μmhos
μ = 20
C_{in} = 3.4 and 2.9 μμf
C_{out} = 2.8 and 2.4 μμf
C_{gp} = 3.0 and 3.0 μμf
Basing 8AC-L-0



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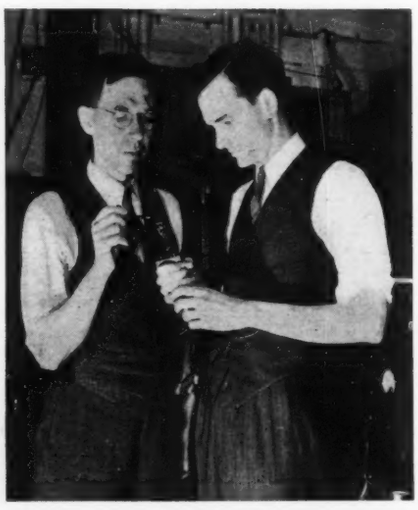
ISOLATE URANIUM ISOTOPES



Drs. K. H. Kingdon (left) and H. C. Pollock of the G. E. Research Laboratory have succeeded in isolating the uranium isotope known as U-235. Uranium tetrachloride was heated in the small electric oven which Dr. Pollock holds. As vapor was formed it was bombarded by an electron beam to form the isotope. The apparatus was placed in a magnetic field of suitable strength

Tube Types Registered by R.M.A. Data Bureau During the First Quarter of 1938

Type 50Z6 (G)

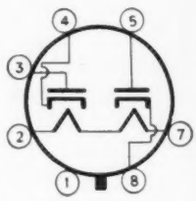
HEAVY duty, high vacuum rectifier, 2 units, single heater, (ST-14) glass envelope, 7-pin octal base.

E_h = 50 v
I_h = 0.3 amp

½ WAVE RECTIFIER
$E_{p\ ac}$ (*rms per plate*) = 250 v (max)
$I_{p\ dc}$ (*per plate*) = 125 ma (max)

FULL WAVE RECTIFIER
$E_{p\ ac}$ = 250 v (max)
$I_{p\ dc}$ = 250 ma (max)
$E_{peak\ inverse}$ = 1000 v (max)

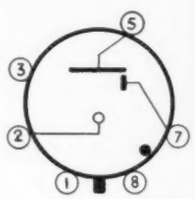
VOLTAGE DOUBLER
E_p = 125 (max)
$I_{p\ peak}$ = 750 ma (max)
$I_{g\ dc}$ = 150 (max)
Basing 7-Q



Type 0A4 (G)

COLD cathode, glow discharge tube, (ST-12) glass envelope, 6-pin base.

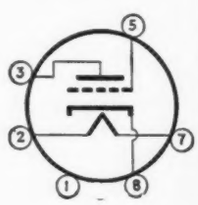
$I_{k\ peak}$ = 100 ma (max)
$I_{k\ dc}$ = 25 ma (max)
E_p (*rms*) = 105–130 v
Basing 4-V



Type 6AC5 (GT)

HIGH mu power amplifier triode, heater type, (T-9) glass envelope, 6-pin octal base.

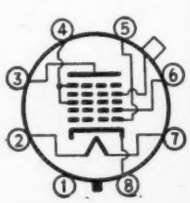
E_h = 6.3 v
I_h = 0.4 amp
E_b = 250 v (max)
E_c = + 13 v
I_b = 32 ma
I_c = 5 ma
r_p = 36700 ohms
g_m = 3400 μmhos
μ = 125
Basing 6-Q



Type 6A8 (GT)

PENTAGRID converter, heater type, (T-9) glass envelope, 8-pin octal base.

E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v (max)
$E_{c3,5}$ = 100 v (max)
E_{c2} = 250 v (max) through 20,000 ohms
E_{c1} = − 3.0 v
I_b = 3.5 ma
$I_{c3,5}$ = 2.7 ma
I_{c2} = 4.0
g_c = 550 μmhos
Basing 8-A



WHAT'S YO
in lo

ABOVE are three typical pages from the General Ceramics Catalog of Steatite and Ultra-Steatite Insulators . . . yours on request.

GENERAL CERAMICS COMPANY
INSULATORS

FCC Opens Door To Frequency Modulation Radio On Commercial Basis

Makes Band Available For FM Broadcasting—Thousands of New Jobs Expected

Simplified F. M. SERVICING PROCEDURE WILL BE DEMONSTRATED AT WESTON'S BOOTH, #411, CHICAGO TRADE SHOW!

WESTON Model 787
U.H.F. Oscillator

WESTON Model 776
direct-reading Oscillator

WESTON Model 772
Super-Sensitive Analyzer

At Chicago, you can get "all the answers" to F.M. servicing by visiting the WESTON booth. The *correct* and *simplified* servicing procedure will be demonstrated and explained by WESTON service engineers. In addition, you will have the opportunity to witness a demonstration of the WESTON Model 787 U.H.F. Oscillator . . . now widely used for F.M. and Television servicing because it is the only service oscillator with frequency coverage from 22 to 150 mc fundamental frequencies, and which reads 40 kc per division at 40 mc. Also the Model 776 Oscillator . . . essential for servicing both F.M. and amplitude modulation receivers because it supplies an absolutely stable signal source; and has an individually hand calibrated scale to insure dependable accuracy over its entire frequency range from 50 kc to 33 mc fundamental frequencies. Other WESTON models, too, will be shown; of the types used in sound laboratories, broadcast stations and for all maintenance and servicing requirements.

Be sure to visit Booth No. 411 and witness these demonstrations. However, if you are unable to attend the show, WESTON will be glad to send you complete information on correct and simplified F.M. servicing procedure. Write to Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark, New Jersey.

Laboratory Standards . . . Precision DC and AC Portables . . . Instrument Transformers . . . Sensitive Relays . . . DC, AC, and Thermo Switchboard and Panel Instruments.

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Specialized Test Equipment . . . Light Measurement and Control Devices . . . Exposure Meters . . . Aircraft Instruments . . . Electric Tachometers . . . Dial Thermometers.

FOR OVER 52 YEARS LEADERS IN ELECTRICAL MEASURING INSTRUMENTS

METAL SHIELDED WIRE (PATENTED)

A New Method of Protecting Insulated Wires

Seamless ALUMINUM, COPPER or BRASS Tubing is drawn over the wire or wires in such a manner that any kind of a bend can be made and the ends easily trimmed.

CHECK THESE ADVANTAGES

(1) The seamless metal shield gives positive protection to the wire against Corrosion, Abrasion, Acids, Oils, Alkalies, Solvents etc.

(2) It is compact, light in weight and neat in appearance.

(3) Tubes made in any required wall thickness.

(4) Outside diameter of the tube can be held to close tolerances.

(5) Practically any number of wires can be shielded by this method.

(6) Armor like protection gives added stiffness, yet easily bent.

(7) Furnished in exact lengths, multiple lengths or random lengths.

(8) Has satisfactorily withstood the severest kind of tests.

SEND FOR FREE SAMPLES

We invite your inquiries and will gladly forward an assortment of samples for your inspection. . . .

See what a practical product PRECISION'S Shielding is. See how easily the leads can be trimmed; try out its bending qualities and ease of installation.

PRECISION TUBE CO.

Specialists in accurately drawn Seamless ALUMINUM, COPPER and BRASS Tubing, in the smaller sizes.

200 OSBORN ST. PHILADELPHIA, PA.

Please send samples of your METAL SHIELDED WIRE to

Name .....

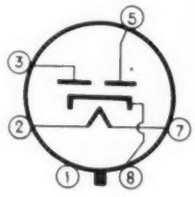
Firm .....

Address .....

Type 6X5 (GT)

HIGH vacuum, full wave rectifier, heater type, (T-9) glass envelope, 6-pin octal base.

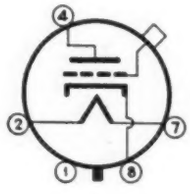
E_h = 6.3 v
I_h = 0.6 amp.
$E_{p\ ac}$ (*per plate, rms*) = 325 v (max)
$I_{p\ dc}$ = 70 ma (max)
Basing 6-S



Type 6F5 (GT)

HIGH mu triode, (T-9) glass envelope, 5-pin octal base.

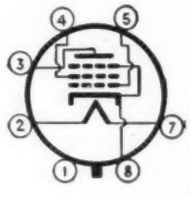
E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v (max)
E_c = −2.0 v
I_b = 0.9 ma
r_p = 66000 ohms
g_m = 1500 μmhos
μ = 100
Basing 5-M



Type 25A6 (GT)

POWER amplifier pentode, heater type, (T-9) glass envelope, 7-pin octal base.

E_h = 25 v
I_h = 0.3 amp
E_b = 160 v (max)
E_{c2} = 160 v (max)
E_c = − 18 v
I_b (*zero signal*) = 33 ma
I_{c2} (*zero signal*) = 6.5 ma
R_l = 5000 ohms
P_o = 2.2 watts (10%)
Basing 7-S



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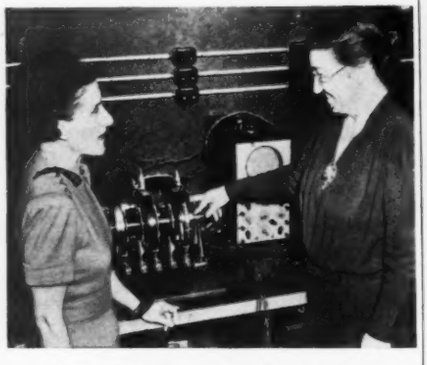
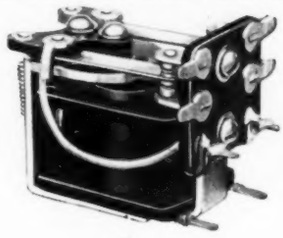
ENGINEERS



Miss Vivien Kellems (left) and Miss Edith Clarke, two of the three women holding full membership in the A.I.E.E. recently met for the first time. Miss Kellems is president of Kellems Products Co. of New York, manufacturers of cable grips and Miss Clarke specializes in power transmission problems at General Electric

Another FIRST... for Advance Relays



Actual Size

An "honest to goodness" Midget Relay—BUT—easily capable of doing a "man sized job".

Entirely of ungrounded construction and equipped with a single mounting stud for "handy" installation.

DIMENSIONS—1½" x ¾"—just slightly smaller than an AIRMAIL STAMP. . . !

COILS—1.5 to 115V A.C. or 2 to 32V D.C., in resistances to 1000 ohms.

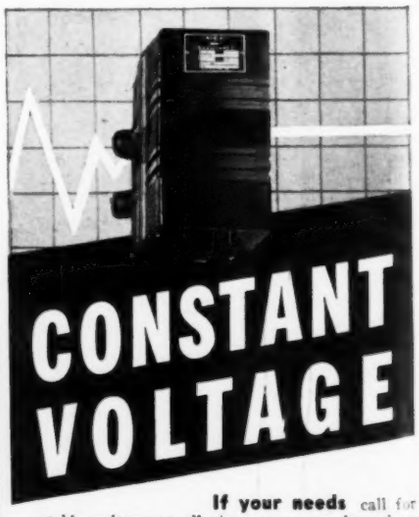
CONTACTS—DP-ST and DP-DT to safely handle up to 200 watt A.C. loads.

Prices and technical data on receipt of your letterhead.

Advance ELECTRIC COMPANY

1260 W. 2nd St., Los Angeles, Calif.

Relay Manufacturers



If your needs call for stable voltage at all times you can depend on

SOLA CONSTANT VOLTAGE TRANSFORMERS

to deliver for you, even though the incoming line voltage varies *as much as thirty percent.* Practical, economical, trouble-free—they can replace non-regulating transformers or perform as auxiliaries to equipment now in use.

WRITE FOR CATALOG
DCV—22

SOLA

SOLA ELECTRIC CO. 2525 Clybourn Chicago, Illinois

IN F M EQUIPMENT, TOO YOU'LL FIND ISOLANTITE INSULATION

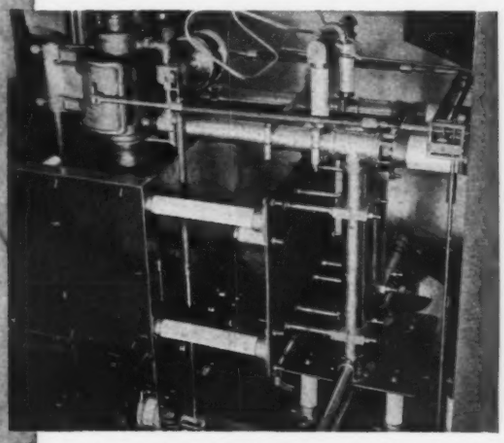
PREFERRED for all types of high-frequency and ultra high-frequency service, Isolantite* is the logical choice for the insulators for Frequency Modulation Equipment.

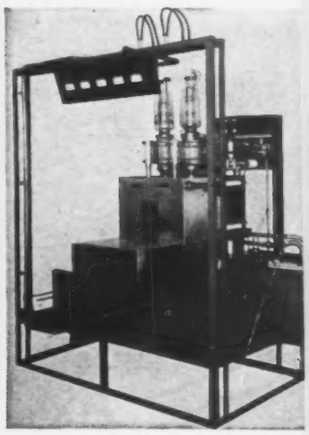
Typical of its use in this new and expanding field is the F M Transmission Equipment at W1XOJ, the Yankee Network Station at Paxton, Mass.

Designed and built by Radio Engineering Laboratories, one of the pioneer manufacturers in the field, this 50 KW Frequency Modulation Equipment makes liberal use of standard Isolantite insulators for all points where low dielectric losses and high mechanical strength are necessary.

To assure peak performance in your F M Equipment, see that it is safeguarded with Isolantite Insulation! Most standard Isolantite insulators are readily adaptable to F M apparatus. The newer types of standoff insulators employing shielded tops which permit reduction in size and increased electrical loading are especially suitable. Where required, special designs will be supplied on order. Our engineers will be glad to work with yours in planning the most efficient insulation for your layout applications.

(*Left*) The 43 megacycle, 4-element turnstile antenna at the Yankee Network F M station, W1XOJ, Paxton, Mass.





(*Above Right*) The 50 KW power amplifier at W1XOJ is shown here before installation in a totally enclosed and shielded room. The two water- and air-cooled AW-200 tubes are clearly visible. Isolantite insulators may be seen in the background.

(*Above Left*) Close-up of the power amplifier unit showing plate lines supported by standard Isolantite standoff insulators.

**Registered Trade-name for the products of Isolantite, Inc.*

ISOLANTITE INC.

CERAMIC INSULATORS

Factory: Belleville, N. J. • Sales Office: 233 Broadway, New York, N. Y.

KENYON

IS READY!

For years Kenyon Transformer Company, Inc., has been solving the transformer problems of American Industry. Modern engineering skill; unusual research facilities, a long and varied experience in the manufacturing of transformers exclusively—all have contributed to place KENYON foremost in the minds of engineers when transformer problems do arise.

We are ready to help solve *your* problems just as we have those of many of America's outstanding companies—a list which is growing more impressive year by year.

FREE CATALOG

Now ready. The finest we have ever produced. Includes Laboratory Standard, Broadcast, Industrial and Plug-in Transformers, Band Pass Filters, many valuable graphs, charts, etc.

KENYON TRANSFORMER CO., INC.

840 BARRY STREET NEW YORK, N. Y.

NEW TRANSMISSION MEASURING SET

The Type 6C Measuring Set provides an accurate and rapid method for measuring the transmission characteristics of networks at audio frequencies.

This new set has the following outstanding features which contribute to its usefulness in the radio broadcasting field.

★ **REFERENCE LEVEL:** New standard of 1 mw. in 600 ohms.

★ **METERS:** New Type 30 standards.

★ **ATTENUATION RANGE:** Zero to 110 db. in steps of 1 db.

★ **POWER RANGE:** Calibrated from —16 to +45 db.

★ **FREQUENCY RANGE:** 20 to 17,000 cycles.

★ **IMPEDANCES:** Dial selection of useful network input and load impedances.

★ **MISMATCH ADDITIONS:** No additions necessary for change of impedance.

TYPE 6C TRANSMISSION MEASURING SET.. $325.00

Write for additional technical information.

THE DAVEN COMPANY

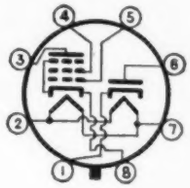
158 SUMMIT STREET NEWARK, NEW JERSEY

The Type 6C was developed in co-ordination with the engineering department of the Columbia Broadcasting System

Type 25A7 (GT)

HALF-WAVE rectifier and power amplifier pentode, heater type, (T-9) glass envelope, 8-pin base.

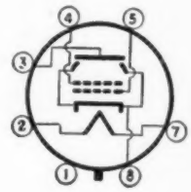
E_h = 25 v
I_h = 0.3 amp
E_b = 100 v (max)
E_{c2} = 100 v (max)
E_c = —15 v
I_b = 20.5 ma
I_{c2} = 4 ma
R_l = 4500 ohms
P_o = 0.77 watts (9%)
Basing 8-F



Type 25L6 (GT)

BEAM power amplifier, heater type, 7-pin octal base.

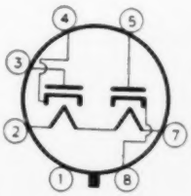
E_h = 25 v
I_h = 0.3 amp
E_b = 110 v
E_{c2} = 110 v
E_c = —7.5 v
I_b (zero signal) = 49 ma
I_{c2} (zero signal) = 4 ma
R_l = 2000 ohms
P_o = 2.2 watts (10%)
Basing 7-AC



Type 25Z6 (GT)

HIGH vacuum rectifier, voltage doubler, heater type, (T-9) glass envelope, 7-pin base.

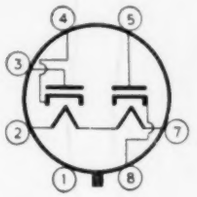
E_h = 25 v
I_h = 0.3 amp
$E_{p\ ac}$ (*rms, per plate*) = 235 v (max)
I_{dc} (*per plate*) = 75 ma (max)
Peak inverse voltage = 700 v (max)
Basing 7-Q



Type 6H6 (GT)

DUO-DIODE, heater type, (T-9) glass envelope, 7-pin octal base.

E_h = 6.3 v
I_h = 0.3 amp
$E_{b\ ac}$ (rms) = 100 v
$I_{b\ dc}$ = 4 ma (max)
Basing 7-Q

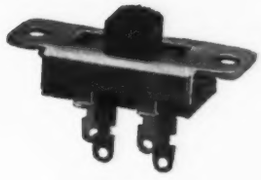


Type 6J5 (GT)

TRIODE amplifier, heater type, (T-9) glass envelope, 6-pin octal base.

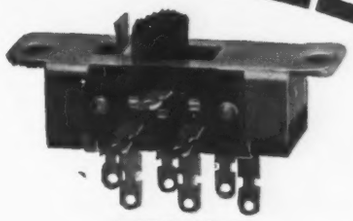
E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v (max)
E_c = —8.0 v
I_b = 9 ma
r_p = 7700 ohms
μ = 20
g_m = 2600 μmhos
Basing 6-Q

For better SLIDE SWITCHES Look to STACKPOLE



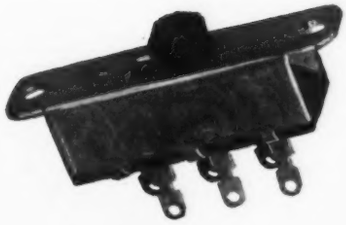
TYPE SS-7

—a three position slide switch which may be used as a three position tone switch, two speed small motor switch with off position or as a bright—dim—off light switch.



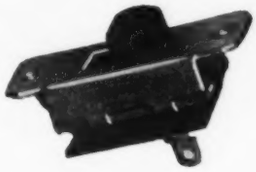
TYPE SS-6

—a TPDT slide switch for use as a change-over switch on portable battery-110 volt sets. Normal installation provides for operation of this switch by insertion of an AC plug in rear or side of set. Switch is returned to normal position by a spring when AC plug is withdrawn.



TYPE SS-3

—a double pole throw switch with Underwriters' Approval which suggests itself for the following uses: Change-over switch for 110 volt battery sets; Band change switch; Phono-radio switch, and many other uses. Supplied also as SS-4—a double pole single throw type.



TYPE SS-1

—a single pole throw switch with Underwriters' Approval for .75 amp. 125 volts. Also supplied as Type SS-2 with three terminals and double throw for: Two-position tone control; Sensitivity control; Change-over switch for AC-DC sets; Line switch for small sets; Small motor control; Tap switch for power transformers; etc.

Illustrations are actual size

If you are responsible for designs in which low cost and space saving are important factors Stackpole's complete line of Slide Switches will exactly fit into your plans. Four types are illustrated here which have a wide variety of applications for handling small power circuits . . . Catalog RC4 gives complete details and diagrams.

WRITE FOR SAMPLES AND PRICES

FIXED RESISTORS • SWITCHES

STACKPOLE CARBON COMPANY

ST. MARYS, PENNA., U. S. A.

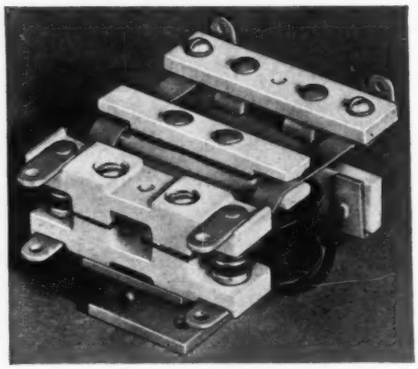
These products are sold only to manufacturers of original equipment.

VOLUME CONTROLS • TONE CONTROLS

PRECISION CONTROL

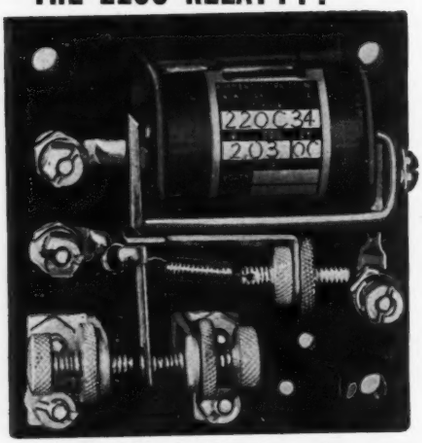
Precise chemical analysis of Magnetic Material.
Precise heat treatment for Magnetic Properties.
Precise Coil Winding, Coil treatment and assembly.
Precise Test and Inspection.

THE 25 RELAY . . .



●This Kurman unit requires one half the power of any similar relay and weighs only 4 ounces. Ceramic Alsimag non-hygroscopic insulation, quarter inch diameter coin silver contacts, self cleaning wipe, cantilever spring action with less than 25% of allowable stress on the spring arms. Entirely new type of laminated magnetic structure. Low power consumption of 1.5 watts; high power output of 2,000 watts.

THE 220C RELAY . . .



●Single pole, double throw, C type coin silver contacts; rated to carry 2 amperes at 110 volts. Precision adjustment. Coil will carry 3 watts without overheating. From 2 to 50 milliwatts input, and loads as high as 1,000 watts.

Cut production as well as experimental costs by specifying Kurman relays for the next job. Write today for descriptive literature; no obligation.

KURMAN ELECTRIC CO. INC
241 Lafayette Street
New York, N. Y.

Type 6J7 (GT)

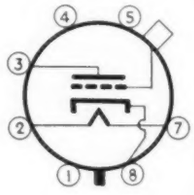
TRIPLE-GRID detector amplifier, heater type, (T-9) glass envelope, 7-pin octal base.

E_h = 6.3 v
I_h = 0.3 amp
E_p = 250 v
E_{c2} = 100 v
E_c = —3.0 v
I_b = 2.0 ma
I_{c2} = 0.5 ma
r_p = 1.5 megohms
g_m = 1225 μmhos
Basing 7-R

Type 6K5 (GT)

HIGH mu triode, heater type, (T-9) glass envelope, 7-pin octal base.

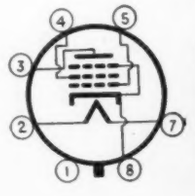
E_h = 6.3 v
I_h = 0.3 amp
E_p = 250 v
E_c = —3 v
I_b = 1.1 ma
r_p = 50,000 ohms
g_m = 1400 μmhos
μ = 70
Basing 5-U



Type 6K6 (GT)

POWER amplifier pentode, heater type, (T-9) glass envelope, 7-pin octal base.

E_h = 6.3 v
I_h = 0.4 amp
E_p = 250 v (max)
E_{c2} = 250 v (max)
E_c = —18 v
I_b = 32 ma
I_{c2} = 5.5 ma
r_p = 68000 ohms
R_l = 7600 ohms
P_o = 3.4 watts (10%)
Basing 7-S



Type 6K7 (GT)

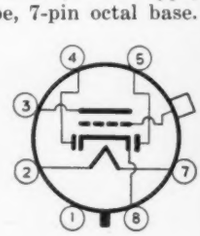
TRIPLE-GRID super control amplifier, remote cutoff, heater type, 7-pin octal base.

E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v (max)
E_{c2} = 100 v
E_c = 3.0 v
I_b = 7.0 ma
I_{c2} = 1.7 ma
r_p = 0.8 megohm
g_m = 1450 μmhos
Basing 7-R

Type 6Q7 (GT)

DUO-DIODE, high mu triode, heater type, (T-9) glass envelope, 7-pin octal base.

E_h = 6.3 v
I_h = 0.3 amp
E_b — 250 v (max)
E_c = —3 v
I_b = 1.1 ma
r_p = 58000 ohms
g_m = 1200 μmhos
μ = 70
Basing 7-V



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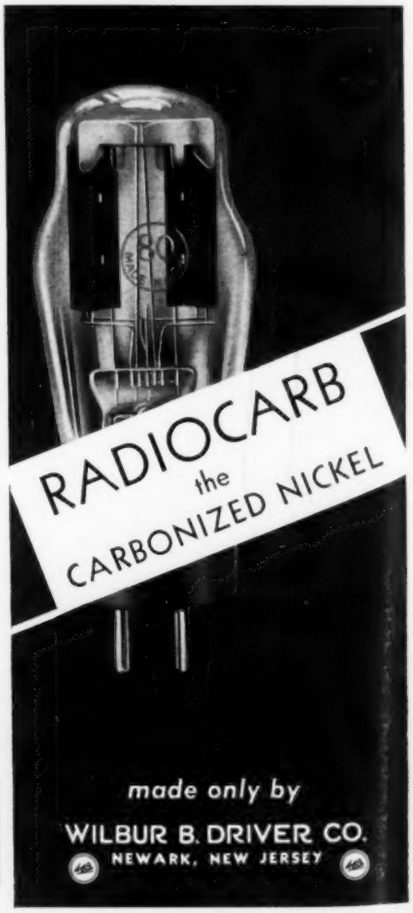

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Recent Books

Electrolytic Condensers

By PHILIP R. COURSEY, *Technical Director, Dubilier Condenser Co., London. John F. Rider, Publisher, New York, 1938, 172 pages.*

ALTHOUGH THE PRINCIPLES of the electrolytic condenser have been known for many years, it has been only in recent years that it has been extensively used in commercial applications. The author gives considerable space to a description of the nature and characteristics of electrolytic condensers and presents the results in a number of curves and diagrams. The other portion of the book is given over to a discussion of the practical types of condensers.

The various types of electrolytic condensers such as the wet, the semi-dry and the dry condensers are described in considerable detail. A chapter is devoted to the separator and its influence on the operation of the condenser. The concluding chapter of the book describes some of the applications of these condensers to radio and to several industrial uses. The book will undoubtedly be of value to the engineer who makes any considerable use of electrolytic condensers or who is engaged in their manufacture.—C.W.

• • •

BANK VAULT ALARM

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Techniques of Recording

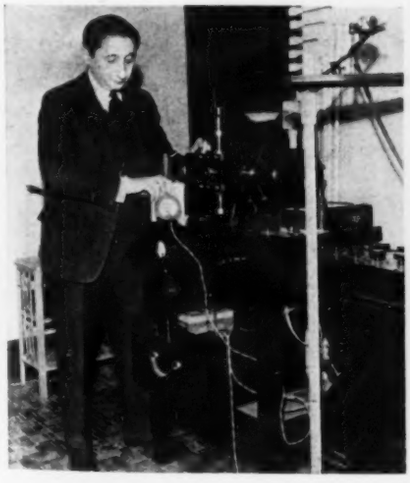
By F. H. GOLDSMITH AND V. G. GEISEL. *Gamble Hinged Music Co., Chicago, 1939, 43 pages.*

THIS BOOK IS SAID by the authors to be a practical handbook on recording. It was written for the beginner in recording and for such a person it provides a good introduction into this fascinating and rapidly growing branch of the art. The authors stick to fundamentals throughout the book without becoming involved too much in details which might confuse the reader. Recording heads and styli, turntables, reproducing needles, record characteristics, and recording practice are discussed sufficiently to enable the newcomer to the field to start work with a moderate knowledge of the technique involved. The point is raised that while quality recordings should be a goal to be realized, quite acceptable results may be obtained by the use of moderately priced equipment. The book is amply illustrated and contains a number of microphotographs of recording styli, reproducing needles, and properly and improperly cut record grooves.

The authors suggest many uses for private recording. Stage and radio artists may improve their technique, speakers may improve their diction and recording may be used as a most effective aid in speech correction.—C.W.

• • •

MACHINE MEASURES NERVOUSNESS AND TENSION



Dr. Edmund Jacobson of the Laboratory for Clinical Physiology in Chicago with his integrating neurovoltmeter which measures nervousness and tension in individuals. It makes use of the minute electrical impulses produced by the muscle and nerves. The instrument shown averages the voltage variations, making it possible to obtain a steady reading which indicates the overall effect of the voltage variations.

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May 24, 1940

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Attention Mr. Fred E. Williamson.

Gentlemen:

We feel that you may be interested in knowing of our success with the Permo Point recording cutters. The results of comperative tests made in our well equipped recording laboratory may also be of interest.

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Our tests show that the Permo Point recording stylus is efficient over a wide frequency, especially in the high range where most cutters fall off in efficiency. These Permo Point cutters consistently make grooves which are just as quiet as those made with our sapphires. Competitive tests, which we have run on various types of steel and alloy cutters, show the Permo Point to have a much longer, quieter cutting life than any we have used of these other materials.

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Recording Engineer

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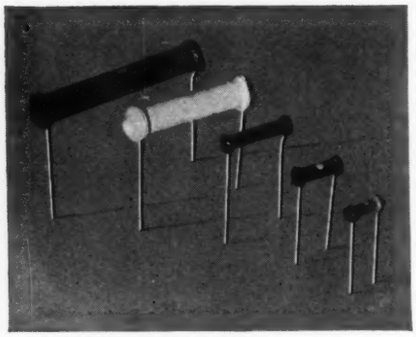

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759-A	1/2	1 OHM TO 15 MEGOHMS	5/8"	3/16"
766-A	1	1 OHM TO 15 MEGOHMS	1"	3/16"
792-A	3	10 OHMS TO 150,000 OHMS	1-3/4"	3/8"
774-A	5	10 OHMS TO 250,000 OHMS	2-1/2"	3/8"

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Panoramic Reception

(*Continued from page* 15)

passes through the pass band, and maximum output will be obtained. If a faster sweep rate is chosen, the output will go down, since fewer r-f cycles will occur. Furthermore, the higher the Q of the transformer, the slower the sweep rate required for full output. However, in all practical cases, unless a very large band is to be covered, full output can be obtained with practical sweep rates.

The transient nature of the reception of each signal has its effect also on the audio-frequency requirements to be met in the receiver. Thus if the intermediate frequency is 455 kc, and 40 cycles of this frequency must occur in the resonant circuits while the signal is present, the time available is 40/455,000, or 1/11,000 second. The audio amplifier must accordingly have a frequency response extending as high as 11,000 cps. In general using practical values of intermediate frequencies, the audio response can be made to fall within the 15,000 cps mark which is not difficult to attain, even in existing audio amplifiers.

The early receivers of the panoramic type, such as that previously described in *Electronics*, employed a motor-driven tuning capacitor to sweep through the band. The disadvantages of this method are the possibility of contact noise at the brushes of the rotating capacitor, and the restricted rate at which the sweep can be made to repeat itself. Unless involved high speed mechanisms are employed, a sweep rate of about 30 per second is the maximum, and furthermore the rate cannot be readily adjusted. The more up-to-date electronic sweep circuit is employed in the modern form of panoramic receiver shown in the accompanying illustration. The electronic sweep employs a reactance tube across the tuned circuit of the oscillator (no periodic tuning is performed in the antenna circuit which is broad enough to accept the band). The reactance tube operates under the control of a multivibrator and amplifier, designed to deliver a saw-

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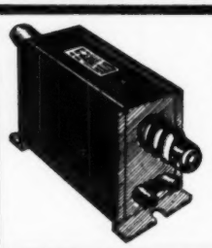

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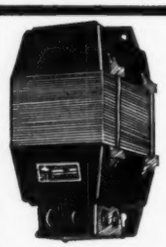

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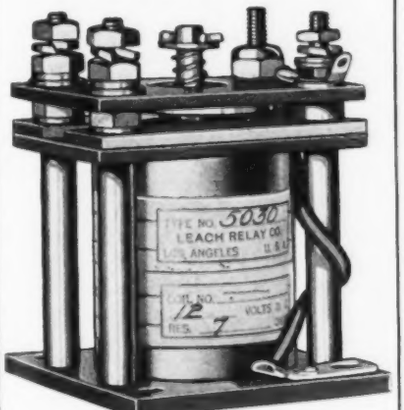

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as a function of its distance in miles, from a geographically fixed point of origin. The screen of the panoramic receiver can, therefore, be actually calibrated in miles, instead of frequency. A topographic scale covering this screen, and indicating the mileage of each beacon, is aligned with the screen, so that each signal appears over the name of its location. One band of frequencies can be used to cover about 250 to 300 miles, a safe "non-repeating" distance for signals of the frequency of 125 megacycles or thereabout.

Instead of operating continuously, the beacons can be rapidly and alternately keyed, so that only one operates at any given moment. This can be done electronically, at any desired rate. If the panoramic sweep is also electronically operated, and if its rate is sufficiently high, the keyed signals can be made to appear simultaneously, as if they were steady signals, with the difference that they overlap and close at the bottom. Such keyed beacon signals have a "characteristic" appearance which cannot be mistaken for any other kind of signal.

The rate of keying can also be made characteristic for various air routes, and by varying the sweep frequency of the receiver so as to synchronize it with one set of beacons, a method of differentiating or "tuning in" one set of beacons from another is provided. If steady carriers are used, (instead of electronically keyed ones), the identification of the signals can be made by occasional "blinking" at a characteristic rate, so as to differentiate one line from another, or one zone from another.

What has been said about long distance navigation applies even more so to problems of instrument landing. In instrument landing three dimensional navigation is required: that means either the use of three conventional receivers, or the use of a single panoramic receiver. What are needed, essentially, are longitudinal indications, in other words, distance to the end of the runway; lateral indications, or a runway localizer; and altitude indications, or a glide path indicator.

The present systems, being based on uni-signal reception, require three different receivers, pre-tuned on three different frequencies. Every

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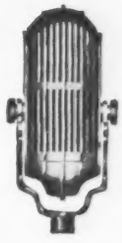

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MODEL 666-H . . . same as Model 666 but with AC-DC Voltage ranges to 5000 volts (self contained) . . . Dealer Net Price $14.50

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The S. S. White Dental Mfg. Co.
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tooth wave of adjustable frequency and amplitude. The reactance presented by the reactance tube (a high-g_m type) succeeds in changing the tuning of the oscillator by a sufficiently large percentage to permit periodic tuning over a band as large as 5 Mc at carrier oscillator frequencies about 125 Mc.

The receiver shown in the photograph is designed for the following specifications: a total frequency sweep range of 5 Mc maximum, 2.5 Mc each side of the center; the center frequency adjustable from 115 to 126 Mc by manual control (by means of the two ganged midget capacitors shown in the photograph). The acorn tubes shown are employed as converter and controlled oscillator. A 6AC7 is used as the reactance control tube, with its socket connected directly at the oscillator tank circuit. A double triode is used for the sawtooth generator which controls the reactance tube, and a single stage i-f amplifier, detector and audio output complete the assembly. A two-inch standard cathode-ray tube is used as the indicator. More elaborate receivers have been built, of course, and would no doubt be advisable for regular service.

The fact that the panoramic receiver can receive a great many stations at once (illustrated for example on the broadcast band panorama shown on the cover of this issue) makes it possible to use the system in conjunction with several beacons stations set up along a navigational line. Dr. Wallace describes this application as follows:

"By operating each successive beacon on a progressively different frequency, each corresponding signal will successively appear on the panoramic screen, gradually increasing in amplitude as the plane approaches, and decreasing as it recedes. Not only can the flier keep on course with the nearest beacon, but what makes this system distinctive is that, from the signal strength ratios of two adjacent beacons, he can know continuously his position between them. This is two-dimensional navigation, as compared with single dimensional navigation, the only possible type of navigation with a receiver depending on a single signal.

"The average frequency assigned to each beacon must be determined according to its geographic location,

Television Receiver

(*Continued from page* 19)

been independently tested it is possible to assemble the units at random, and no further test is applied but a check to see that the cathode-ray tube chosen for the assembly and the entire unit operates satisfactorily on a single channel. This final operating test is generally applied after complete assembly in the cabinet.

Twenty-Inch Tube

The television receiver which has been described is designed to employ either the 14-inch tube which so far has been the commercial standard or the newly released 20-inch cathode-ray tube which is illustrated here. While the 14-inch tube provides a picture approximately 8 inches by 10 inches which is of reasonable size for many installations, the 20-inch tube gives a picture sufficiently large to be observed from any point in the average living room. Tests on the 20-inch blank in operating conditions have shown that the strains in it are no more serious than those in the 14-inch tube.

The Type 195 20-inch television receiver contains an all-wave radio as its sixth sub chassis. Also in light of the flexibility of television transmissions as recently recommended by the Federal Communications Commission this receiver incorporates a switch allowing selection of two pre-set combinations of line and frame frequencies. Since automatic circuits are difficult to build to accommodate both the R.M.A. synchronizing signal and the more recently proposed Du Mont signal with the high frequency vertical pulse, it was deemed best for this transition period at least to provide for both the R.M.A. and Du Mont type of synchronizing signals which is most practically done by an actual selector switch. The range of the sweep controls of this unit is sufficient to cover line and frame combinations from 625 lines at 15 frames to 507 lines at 30 frames so as to be able to accommodate all reasonably logical transmissions which are expected in the near future.

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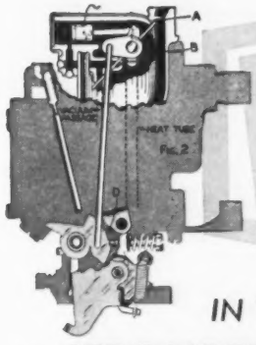

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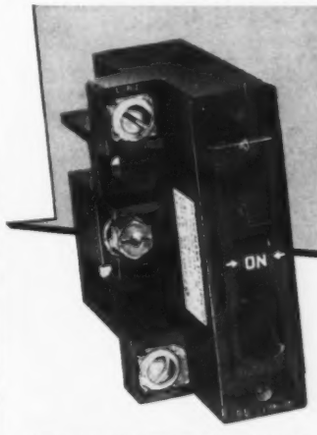

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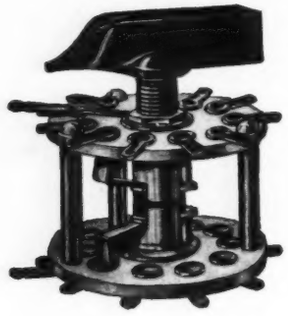

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one is used either as a signal strength indicator (marker beacon receiver and glide path receiver), or as a means for comparing signal strengths (runway indicator). Although three different receivers are used, there is still a compromise between safety and convenience.

The longitudinal indications are produced by two marker beacons, which are two small oscillators, one placed about two miles from the end of the runway, and the other within a few hundred feet. The two oscillators must operate on the same frequency, so as to use one single unisignal receiver for the two.

This means that no indication is received as to distance to the end of the runway between the moment when the pilot is informed that he is within two miles from it, and the moment when he knows that within six seconds he must touch the ground. Furthermore the glide path indicator is based on the absolute field strength reading of that unisignal receiver, instead of being based on a comparison, which is always safer.

By utilizing panoramic reception, on the other hand, the runway localizer can be a dual frequency beacon, such as described above, operating at a standardized average frequency.

The glide path indicator can also be a dual frequency beacon, at a different frequency. The equipotential path of this latter beacon, is produced by two patterns of propagation which differ in the vertical plane: one radiator, putting, for example, a lobe practically parallel to the ground, and another one, on adjacent frequency, having a slightly higher vertical lobe.

A series of markers (simple oscillators) at still different frequencies, are located, for example, at every half mile along the runway, and so disposed that when the plane is above them, it receives their signals at an amplitude equal to either localizer or glide path indicator. Their frequencies are progressive and indicative of distance from the end of the runway, as explained in connection with the long distance beacons. The pilot sees, from their continuous field strength variation, at all times his position, and he knows at all times how far he is from the end of the runway.

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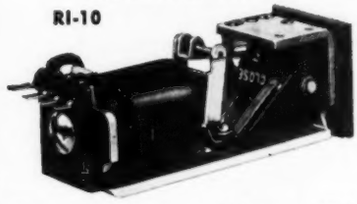

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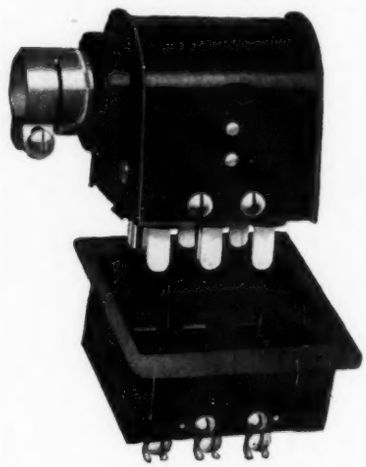

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THE ELECTRON ART

Method of telephoning in noisy locations, magnetron oscillators, location of buried cables, patent searching and an infra-red phototube are the subjects taken from periodicals this month

The Laryngophone

A METHOD BY WHICH TELEPHONIC COMMUNICATIONS may be maintained in very noisy surroundings is described in "The Laryngophone" by J. de Boer and K. de Boer in the *Philips Technical Review for January*, 1940. Ordinary microphones cannot distinguish between the desired sound and any other desired sound that may be present. It is necessary therefore that they be used in surroundings where a disturbing sound is not too great. In order to conduct telephone conversations in airplane cabins, boiler factories, shipbuilding yards, mine shafts and other very noisy places a new technique of converting voice sound into electrical energy was developed. A new device, the Laryngophone is not actuated by sound emanating from the mouth of the speaker, but by the mechanical vibrations of the vocal chords in the throat. This is done by placing the Laryngophone in close contact with the outer surface of the throat in close proximity to the vocal chords. The Laryngophone may be compared to a phonograph pick-up in that its operation is not affected in any manner by sound in the air.

The authors discuss briefly the mechanism of speech production to show that the throat vibrations have approximately the same form as the air vibrations which occur during speech. This approximation is close enough so that the Laryngophone has an intelligibility which is close to that of the air microphone.

There were two kinds of laryngophones developed, a crystal unit in which quality was of prime importance and a carbon unit which was designed for the greatest possible sensitivity. The utility of the new instrument can be tested by quantitative determinations of the intelligibility. In such tests it was shown that ordinary telephone apparatus gives an intelligibility of about 90 per cent in surroundings of low noise levels. This compares with an intelligibility of 86 per cent for the crystal laryngophone and 77 per cent for the carbon laryngophone. Under conditions of severe noise level the intelligibility of the crystal unit decreased to about 80 per cent, the carbon unit to 68 per cent and the ordinary telephone to 0 per cent. The 68 per cent mentioned for the carbon unit is high enough to enable one to follow a conversation and thus certainly high enough to be able to make understandable orders or similar communications of a familiar recurring nature. Also, the intelligibility can be further increased by using telephone lines with a better frequency characteristic than is usually the case.

The most important possibilities of application for the laryngophone have already been mentioned. In these troubled days of destruction of life and property over a considerable portion of the world, another application becomes of prime importance. It is the use of the laryngophone in combination with gas masks. An air microphone is quite useless in this case because of the resonances in the small sealed air space inside the mask. This difficulty is overcome when a laryngophone is used. It also has the added advantage that it can be passed from one speaker to another without it being necessary to open the mask.

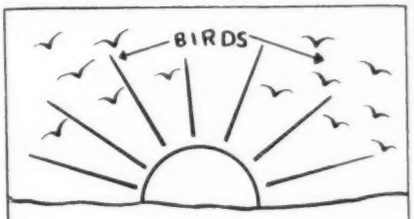
Magnetron Oscillators

IN THE MARCH, 1940 issue of the *Journal of the Institute of Electrical Engineers* (London) three articles discuss the operation of magnetron oscillators: "An Experimental Investigation of Resonance and Electronic Oscillations in Magnetrons," by J. S. McPetrie and L. H. Ford, "A Magnetron Oscillator with a Compound Field Winding," by L. H. Ford and "The Impedance of the Magnetron in Different Regions of the Frequency Spectrum," by A. F. Harvey. The results described in the first paper show that the same resonance oscillations occur in both single and multi-segment anode tubes having similar dimensions, but that by dividing the anode into a number of segments certain types of these resonance oscillations become predominant. As these resonance oscillations occur in a full-anode magnetron, it would appear that the precession of electrons occurs even in the absence of any alternating component of electric field between the segments of the magnetron, but that the effect becomes more pronounced on division of the anode into a number of separate segments.

The second paper discusses the possibility of using the anode current to excite additional coils on the electromagnet of a magnetron oscillator and thus control the magnetic field. When the anode current assists the main magnetizing current, the benefits are rather doubtful, but when the anode current opposes the magnetizing current, advantages as a generator of

ELECTRON CAMERA

The electron microscope and camera shown above has been installed at the Case School of Applied Science to study crystals and atomic structure in researches conducted to lessen wear, corrosion, friction and other destructive forces. It records streams of electrons rather than light rays



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resonance oscillations are gained. It is possible to improve the stability of the oscillator by this method. It also removes the danger of overheating the anode if the load is suddenly removed.

The third paper gives a description of a series of measurements on the impedance of the magnetron and its relation to the operating conditions in different regions of the frequency spectrum. The object of the experiments was to understand and explain the mechanism of operation of the magnetron. This has not been completely possible and it appears that a full explanation is difficult unless existing theories of electron motion in the magnetron especially under dynamic conditions are much extended. A number of curves are shown to illustrate these results.

• • •

Measuring Radio Noise

THE MARCH 1940 ISSUE of *Electrical Engineering* contains an article entitled "Instruments and Methods of Measuring Radio Noise," by C. V. Aggers, Dudley E. Foster and C. S. Young. It is essentially a discussion of the recommendations of the point coordination committee on radio reception of E.E.I., N.E.M.A. and R.M.A. as to the nature, essential characteristics and performance of an instrument for the measurement of radio noise voltages. Various types of apparatus produce radio noise of varying characteristics; some types of noise have high amplitudes and short duration and others are of a more nearly sinusoidal form. Also the circuits of the radio receiver upon which the noise impinges will have an affect on the noise characteristics so that the character of the noise at the output may differ materially from that at the input.

The noise meter designed to measure the characteristics of the noise source as it exists at the input to a receiver would be very complex and cumbersome. The most practical type of instrument is one essentially similar to a radio receiver with an indicating instrument in the output. It can therefore be made convenient to operate, portable and reliable. There are three general types of output indicators; oscilloscopes, wave form analyzers and indicating meters. The indicating meters are convenient and reliable and are therefore preferred for general use. The characteristics of the circuit of the meter are discussed in considerable detail.

The methods for the measurement of radio noise produced by various types of electrical apparatus are described. At the end of the article there is considerable discussion by leading engineers of the industry and additional discussion by the authors.

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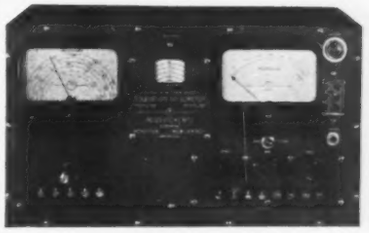

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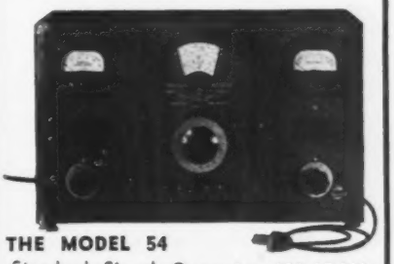

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Microorganisms in High Frequency Fields

IN RECENT YEARS THE USE OF RADIOTHERAPY in the treatment of a variety of human ills has received wide application. There have arisen several controversial questions relative to the nature and specificity of the action on tissues of organisms at different frequencies. Messrs. Francis M. Summers and Harold K. Hughes present a report entitled "Experiments with Colpidium Campylum in High-Frequency Electric and Magnetic Fields," in the April, 1940 issue of *Physiological Zoology*. The purpose of the experiment was to investigate the possibility of an effect of high frequency fields and biological organisms which cannot be shown to result entirely from heating. A large number of organisms were exposed individually to electric and magnetic fields of frequencies from 15 Mc to 60 Mc under conditions of constant temperature and controlled environment. Direct microscopic observations were made before and after exposure.

The previous literature pertaining to this subject is discussed in considerable detail. The authors point out the position which is occupied by their own experiments in the development of the broad subject of radio-therapy. From the results of these experiments the conclusion is reached that there is no large-order effect on the physiological organization of the microorganisms (colpidium campylum) which can be attributed to the nonthermal mode of energy transfer from high-frequency electric or magnetic fields in a range of frequencies from 15 Mc to 60 Mc.

• • •

Infra-Red Photocell

A PAPER WAS PRESENTED at the General Meeting of the Electrochemical Society in April at Wernersville, Pa., by Colin G. Fink and Johnstone S. Mackey entitled "Photoelectric Cells Sensitive to Long Wave Radiation. The Bismuth Sulfide Cell." It also appears in Preprint No. 77-13 of the Society. The principal development described was the use of bismuth sulfide as a photoactive element. The greatest sensitivity of this substance is at about 70,000 Angstroms and about 80 per cent of its activity lies in the infrafred portion of the spectrum.

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The paper describes the experiments in considerable detail and a comparison of various materials and methods is given in many of the cases. The results of a number of tests on the new photocell are given in the form of a series of curves.

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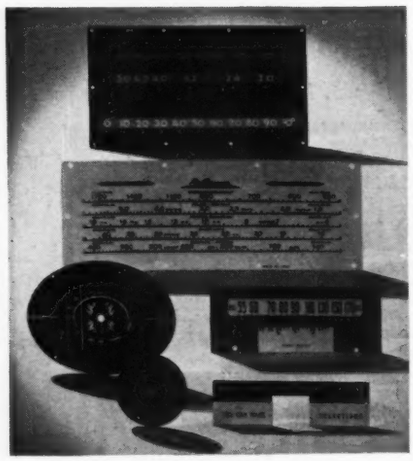

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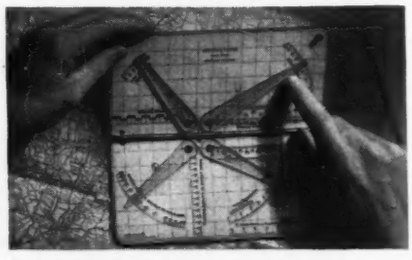

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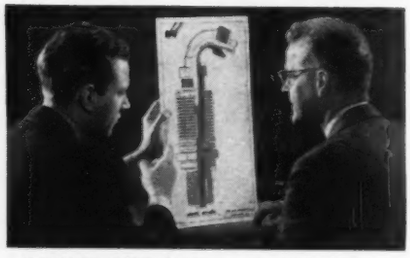

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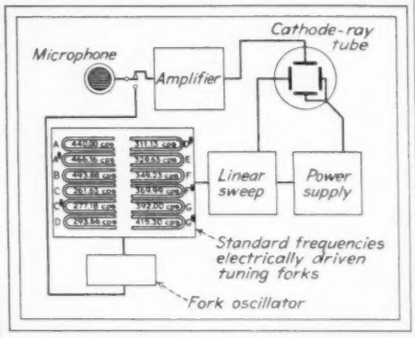
The Resonoscope

AN INSTRUMENT which provides an accurate means of tuning musical instruments is described in "The Resonoscope," by S. K. Wolf and L. B. Holmes, in the May 1940 issue of the *Journal of the Society of Motion Picture Engineers*. The instrument consists essentially of a set of standard electrically driven tuning forks, a cathode-ray tube and the associated amplifiers. The twelve tuning forks have tones corresponding to the twelve notes of the chromatic musical scale, which are used to synchronize an oscillator which provides a horizontal sweep for the cathode-ray tube. A microphone which picks up music or a single musical tone is then connected



Block diagram of the resonoscope, used in tuning musical instruments

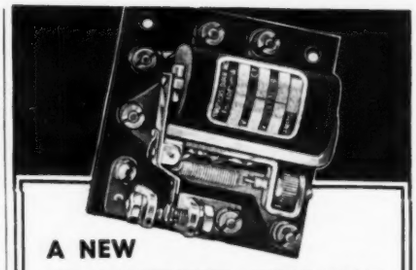
to the vertical plates of the cathode-ray tube.

This gives a visual picture of the wave form of the tones. If the musical note is of the same pitch as the standard tone of one of the tuning forks, or any harmonic of it, the wave will appear to stand still on the screen. If the note is flat, or lower in pitch than the horizontal sweep standard, the wave will appear to move to the left. If the note is higher in pitch or sharp, the wave will move to the right. This gives an indication to the musician whether he is playing in tune, sharp or flat. Also, the speed with which the wave moves across the screen is a direct indication of how much the instrument is out of tune.

• • •

Radio Exports

THE BUREAU of Foreign and Domestic Commerce of the U. S. Department of Commerce has issued the statistics of radio exports for the year 1939. The statement gives export figures on radio, telephone and welding equipment to a large number of foreign countries. The value of the transmitters exported was $2,700,000; receivers $10,000,000; tubes $3,000,000, loud speakers $575,000 and other components $5,500,000. A copy of this statement may be obtained from the Department at a cost of 10 cents.



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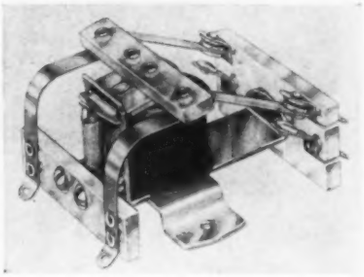

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patent literature, books and periodicals are of considerable value. It is interesting to note that papers delivered before scientific or other bodies have no standing as publications in patent work. The article closes with a few hints on how a private patent library may be built up.

• • •

Filters Employing Crystals

A DISCUSSION OF filters making use of crystals appears under the title "Electrical Wave Filters Employing Crystals with Normal and Divided Electrodes" by W. P. Mason and R. A. Sykes appears in the April 1940 issue of the *Bell System Technical Journal*. Filters of this type have been widely used in both radio systems and in carrier telephone systems in this country and abroad. The article discusses all of the standard types of filters with crystals and methods for determining their constants and attenuation characteristics. In addition, some of the newer results for simplifying such filters are given. The theory of the use of a divided plate crystal in filters is discussed and an equivalent circuit for a crystal with two sets of plates is given.

• • •

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An inmate of the Southern Michigan Prison, at Jackson, has invented the small radio receiver shown here for use by policemen on their beats. Eight loops of wire woven to form a Sam Brown belt act as the antenna and tune the first stage to the frequency of the local police transmitter. The receiver is battery operated, uses three tubes, and is designed to be worn on the policemen's belt. An earphone is attached to the antenna and fits on the shoulder near the ear.

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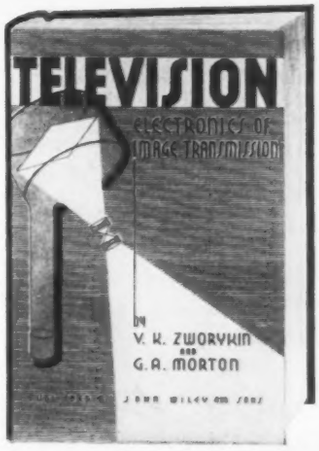

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FEBRUARY 1940
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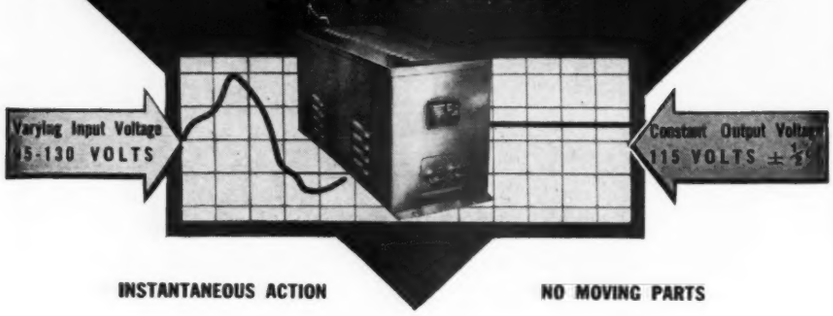

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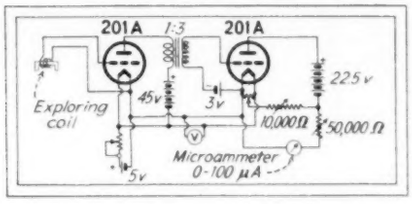
Buried Cables and Pipes

"LOCATING BURIED CABLES and Pipes," by H. C. Marcroft, appearing in May 1940 issue of *Instruments*, describes a device for locating, without digging, cables, pipelines, conduits and other metallic conductors buried in the ground or in concrete floors and walls. The circuit of the instrument is shown in the accompanying diagram. It consists of a magnetic pick-up coil on a U-shaped iron core, a battery operated vacuum tube amplifier and an indicating instrument. It has suffi-



Circuit diagram of the buried cable detector

cient sensitivity to detect a 60-cycle current of 2 or 3 amperes at a distance of 1 foot. Cables carrying direct current can easily be detected if the current is generated by a d-c generator. This is made possible by the commutator ripple. In cases where the cables are shielded in iron conduits there is generally enough ground current to operate the detector, or where it is necessary, current may be passed through the conduits. By the use of this instrument iron conduits have been located as much as 13 feet underground with no difficulty.

• • •

Patent Searching

"PATENT SEARCHING, WITH SPECIAL REFERENCE TO CHEMICAL PATENTS," by Miles O. Price, which appears in the April, 1940 issue of *Special Libraries*, the official journal of the Special Libraries Association, is found to be well worth reading by radio engineers, even though patents in the chemical field are emphasized. The fundamentals of the patent procedure are the same regardless of the type of patent in question.

The author first sketches the various requisites of patent facilities, that is, what is patentable and what is not. He then tells of the relation between previous patents and literature covering the subject matter in question to the present application. The various types of patent searches for different purposes are covered. Procedure of the search is outlined in considerable detail with the differences in the different kinds of searches pointed out. The classification of patents in a patent office is stressed. It has some 320 classes, and 33,000 sub-classes. Obviously the searcher must be familiar with the classification and this is possible only after considerable experience and effort. To supplement the use of

F-M: Wide Band vs Narrow Band

(*Continued from page 29*)

dicator and even then it must be tuned very carefully. The receiver designed for transmitter swing of 60 kc is somewhat better than 30 kc but still less than one half the ease of the 150-kc swing. This, of course, is due entirely to the ratio of the band width to the total band. The possibility of providing the receiver designed for swings of 30 kc with preset "push button operation" is quite difficult and this leads to the problem of oscillator drift, which, while not insurmountable, will certainly cause receivers to be more costly for the lower transmitter swings.

The drift of the receiver designed for the 30-kc swing is no different than that of 60 kc or 150 kc, since the oscillator constants must necessarily be the same because the employed frequencies are the same. Practically, on the receiver designed for a 150-kc swing a 20-kc oscillator drift is usable. That is, if the oscillator of the receiver from cold to hot (a period of 25 to 60 minutes) drifts 20 kc, the receiver is still sufficiently broad to cause no intolerable distortion, although it would probably be desirable to retune after about 15 minutes from the time of starting, depending on the strength of signal. Thus, in a receiver designed for 150-kc swing a 15-kc oscillator drift, which is easily obtainable with some compensation would not be noticeable by the user. This is only 10 per cent of the total swing. Now, if we have these same values on the receiver designed for 30-kc swing, a 20-kc oscillator drift would tune the receiver to the fringe of the next channel. An oscillator drift of 15 kc would detune the receiver to intolerable distortion in the first 10 minutes, the succeeding 20 minutes and the succeeding 40 mintues. The receiver would have to be retuned at least three times, which is not a practical operating characteristic and would make it impossible to use preset stations unless extensive means were used to correct the condition. Further, the al-

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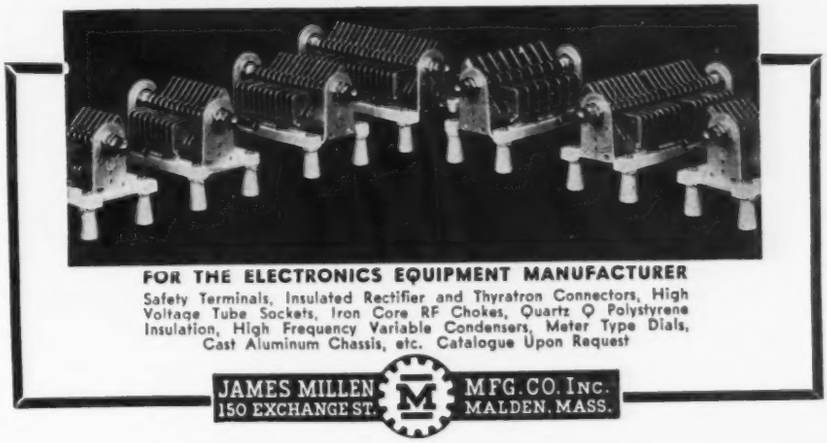
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Electron and Ion Beams

BEAMS OF ELECTRONS AND POSITIVE IONS are of great importance in modern electronic devices and present research indicates that in the future they will be of even greater importance. Messrs. Lloyd P. Smith and Paul L. Hartman, both of Cornell University, contribute to the literature on this subject in an article entitled "The Formation and Maintenance of Electron and Ion Beams" in the March, 1940 issue of *The Journal of Applied Physics*. They state in this article that considerable difficulty has been experienced in obtaining positive ion beams of high intensity and in some cases in obtaining such beams of electrons. They show that there is a definite upper limit to the current that may be obtained in a beam of given crosssection under specified voltage conditions and that for positive ions this current is quite small. The problem of beam formation divides itself naturally into five parts: (1) that of keeping the ions together during the period of initial acceleration; (2) the space charge divergence throughout the remainder of the beam length; (3) that of preventing divergence over the high velocity region; (4) the radial potential or velocity distribution in the beam and (5) the maximum beam current that can be realized. These aspects of the problem are discussed in detail and various practical methods of holding the beams together are discussed.

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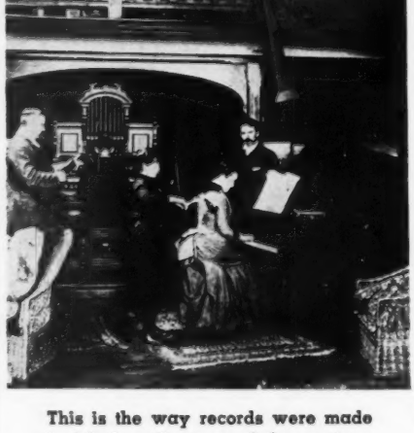
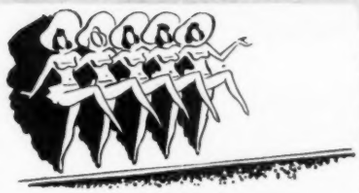
EARLY RECORDING METHOD



This is the way records were made just before the turn of the century. The sound was collected by the long horn and carried to the recorder at the top where the engraving stylus was actuated directly by the variations in the air pressure



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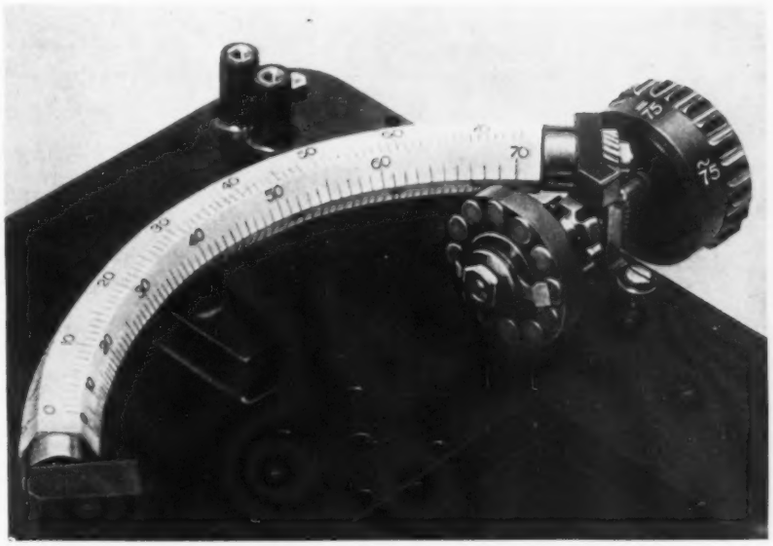
THE INDUSTRY IN REVIEW

A Simplified Multiple Scale for Measuring Instruments



The Rotoroid scale provides a number of scales, each of different characteristic, but of the same length, for measuring instruments

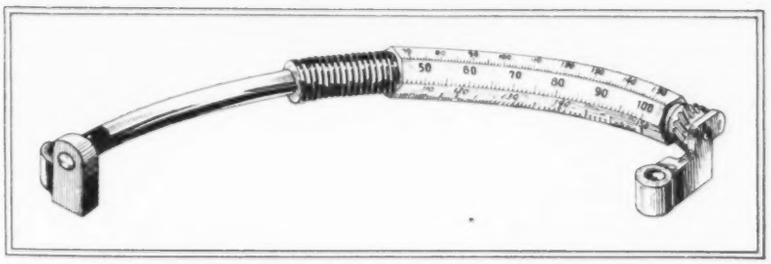


Diagram showing construction of the multiple scale

This multiple scale may be applied to complete circles or even to spirals. This feature considerably broadens its field of application

A NEW and interesting device which simplifies the use of measuring instruments possessing a number of different scales has come to the attention of the editors. It is the Rotoroid Rotating Scale manufactured by the Rex Rheostat Co., 37 West 20th St., New York. In addition to its use in electrical measuring instruments such as voltmeters, ammeters, etc, the Rotoroid scale has many other fields of application. It may be applied to radio receiver dials, tachometers, weighing scales, photographic exposure meters and other instruments which require a multiplicity of ranges.

There are several drawbacks to conventional multi-range measuring instruments. One of the most important of these shortcomings is the confusion in reading a scale caused by the presence of a number of other scales, especially when there are as many as six or seven scales on the meter. Also, there is always the danger that the incorrect scale may be used or that the wrong multiplier might be applied to the correct scale. Another disadvantage is that if the scales are arranged on concentric arcs, the inner scales are much shorter than those further from the center. The accuracy of the shorter scales is considerably less than the longer ones and they are more difficult to read.

The ideal arrangement is to have only one scale visible at a particular time and to have each scale of the greatest length possible. The Rotoroid scale provides this for as many as six scales. The mechanical construction is shown in the accompanying photograph and diagram. A solid metal rod is formed in the arc of a circle of the proper size to suit the instrument. Over it is placed a seamless corrugated metal tube which is flexible to bending so that it may be turned in an arc of a circle and at the same time is highly resistant to torsion so that there will be no angular displacement. To provide a flat surface on which to place the scale, a hexagonally shaped (outer surface) rubber tube is placed over the corrugated tube. The unit is turned to make other scales visible by turning a knob on the exterior of the instrument and at the same time series or shunt resistances are switched in or out of the circuit to change the range. To prevent any change in the length of the scale due to changes in temperature, both ends of the corrugated tube are rigidly fixed in position.

Besides overcoming the disadvantages of the conventional scale arrangement of measuring instruments, the Rotoroid scale, permits two observers to read the scale with accuracy. This is done by exposing two surfaces each with a scale on it, extending the pointer to cover both scales and by providing an extra mirror to avoid errors due to parallax.

This new device is not limited to small angles of operation or to the arc of a circle. The shape of the scale does not matter and if necessary may be any irregular curve. It is possible to use it in an instrument which requires that the dial occupy slightly less than 360 degrees or almost a complete circle as shown in the accompanying photograph.

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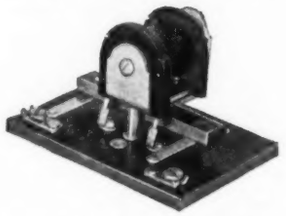
lowable shift in center frequency of the transmitter is ±4 kc at 43 Mc. This eliminates the possibility of temperature compensation of a receiver designed for 30 kc swing, because an 8 kc shift is 26 per cent of the total swing without the drift of the receiver itself. While automatic frequency control might be employed, this materially increases the cost of the receiver to the buying public. Furthermore, the effects of extreme noises such as diathermy which would operate the afc might prove very unsatisfactory on weaker signals because of the particular character of diathermy. The effect would probably act to "wobble" the oscillator frequency of the receiver for some signal strengths. The receiver designed for swing of 60 kc could probably be temperature compensated satisfactorily. It is to be noted here that the oscillator drift will vary with the amount of heat present in the receiver, the construction of the cabinet and the variable elements not under control of the manufacturer, such as proximity to a wall, radiator, etc. Thus, it can be seen that for practical operation for satisfactory public acceptance, a wide band is very desirable.

In conclusion, the results of the measurements taken on these receivers, especially designed for the various transmitter swings, point out that signal-noise ratios of the order of 30 to 35 db are not good enough when all external noises are eliminated and the frequency range is extended to 10,000 cps and above. The transmitter swing of 150 kc and measured signal noise ratio of 62 db still leaves much room for improvement of transmitter noise, receiver noise at low field strengths, (better limiting circuits) and studio amplifiers and microphones. Any system of less swing than 150 kc sacrifices the possibility of quiet operation over the frequency range, extended to 10,000 cps and beyond in this system, since improvements at the transmitter and studios always leave the margin of the advantage of the 150-kc swing over lower swing systems.

The results of two frequencies operated on the same channel show the superiority of the 150-kc swing over all other systems of narrower bands. This also holds for the results of stations which operate on adjacent channels.

RELAYS! by STACO



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Electric Soldering Irons. Catalog No. 100 combines previous separate sheets on screw tip irons, plug tip irons and tip service plus some new additions. Hexacon Electric Co., 151 W. Clay Ave., Roselle Park, N. J.

Standardized Bearings. A nicely indexed 64-page book, catalog No. 40, gives information on cast bronze and sleeve type bearings. The Bunting Brass & Bronze Co., Toledo, Ohio.

Test Equipment. In this new edition of a catalog (No. 122) on test equipment, several new test instruments are included. Radio City Products, 88 Park Place, New York City.

Amplifiers. Two bulletins are available on amplifiers. The first deals with a push-pull Class A 10 and 20 watt amplifier, while the second tells about a 30 watt all push-pull direct coupled amplifier. Both of these pamphlets are available from Amplifier Co., of America, 17 West 20th St., New York City.

Radio Service Encyclopedia. "Half-Wave and Doubler Power Supply Systems" is the subject treated in Supplement No. 6 to the 3rd edition of Mallory-Yaxley Radio Service Encyclopedia, of P. R. Mallory & Co., Indianapolis, Ind.

Springs and Stampings. Spring and wire forms, stampings and assemblies, are illustrated and described in a 4-page bulletin. Hunter Pressed Steel Co., Lansdale, Pa.

Radiotelephone Equipment... A folder describing and illustrating marine radiotelephones is available from Harvey-Wells Communications Inc., Southbridge, Mass.

Electronics Products. Engineering bulletins are bound together in one folder for easy filing. The file folder contains information on an image dissector, telecine projector, telecine channel, master timer and pulse generator, mobile equipment, and multiplier tubes. This file folder is available from Farnsworth Television & Radio Corp., Fort Wayne, Ind.

Supplement Sheets. Raytheon Production Corp., Newton, Mass., announce a supplement to their databook, bringing this publication up to date with the characteristics of 73 types of recent locking base, single-ended metal, bantam and octal based tubes.

Nickel Alloy Guide. A general guide to the uses and properties of nickel and high nickel alloys is incorporated in a new illustrated booklet which is available from International Nickel Co., 67 Wall St., New York City.

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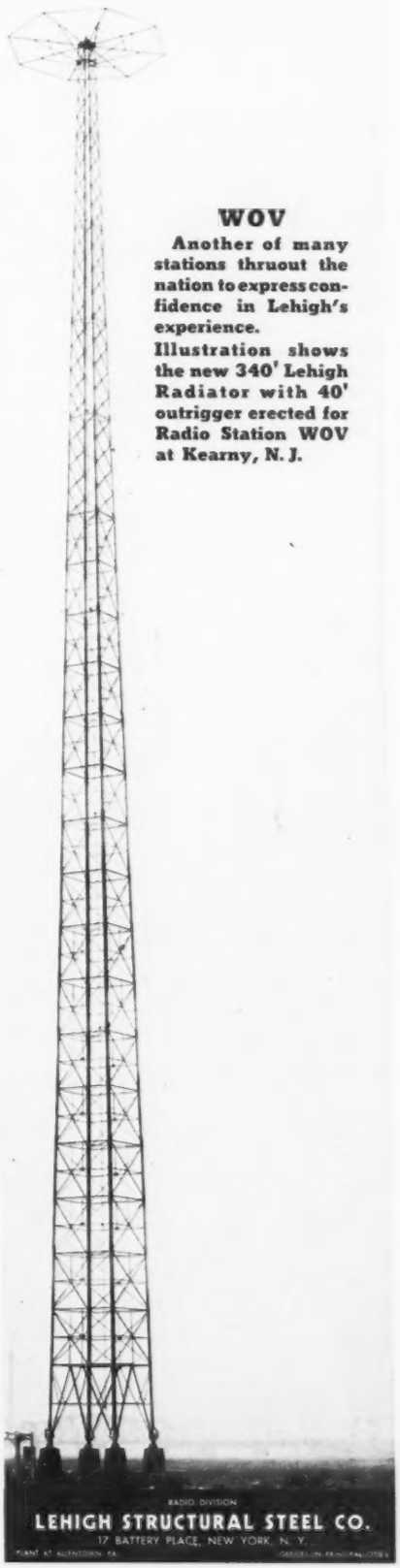

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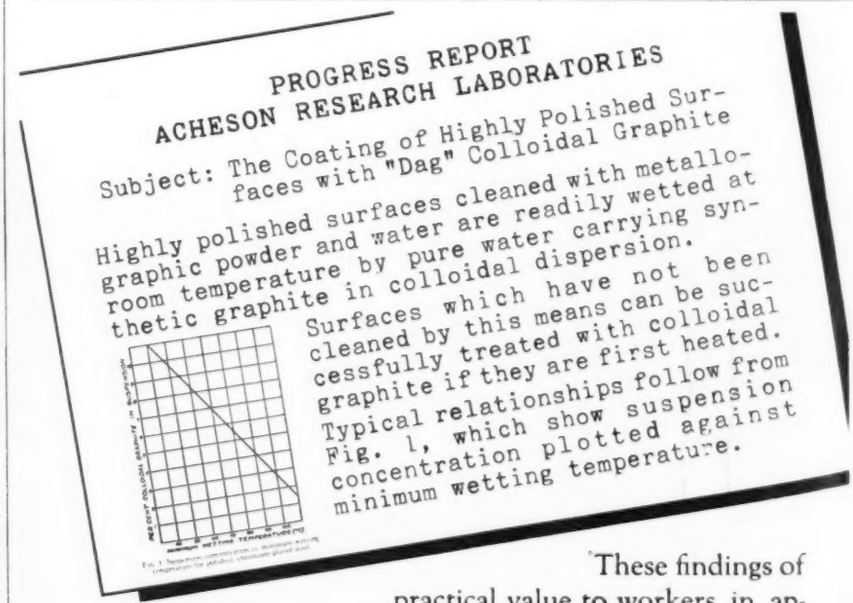
News

✦ A paper and an accompanying demonstration were presented recently before the Society of Motion Picture Engineers in session at Atlantic City, showing the very compact portable-mobile television pickup equipment of the Du Mont Laboratories . . . F.C.C. recently licensed Du Mont to construct a new television station in New York City . . . Games Slayter of Newark, Ohio, who made thread-like fibers out of glass has been awarded an Edward Longstreth medal from the Franklin Institue for his development of Fiberglas . . . United Cinephone Corp. announces the removal of their offices and plant from Long Island City, N. Y. to Torrington, Conn. . . . A prize contest open to engineers, physicists, laboratory workers, servicemen, and others, dealing with new and practical applications of the cathode-ray tube and allied equipment, is announced by Allen B. Du Mont Labs., Passaic, N. J. The contest extends from June 1st 1940 to May 31st, 1941 . . . Philco Corp., Philadelphia, heretofore a privately-owned corp. has amended the articles of incorporation to clear the way for public ownership . . . Lt. Colonel Gustavus Reiniger who pioneered network broadcasting as a star-salesman for National Broadcasting Co. has joined Radio Engineering Laboratories, Inc. as a sales-manager . . . Loyal V. Bewley, of Pittsfield, Mass., research engineer with the General Electric Co., has been appointed Professor of Electrical Engineering and head of the department at Lehigh University . . . The Essex Wire Corp., Detroit, Michigan, announced that Mr. W. J. Shea has been elected Vice President and will be in complete charge of the magnet wire division at Fort Wayne, Ind. . . . The S. S. White Dental Mfg. Co., recently honored three of its employees, D. W. Sprague, C. E. Boyd, and W. H. Berke, who have each recently completed sixty years of uninterrupted service with that Company . . . Telex Products Co., Minneapolis, Minn., has taken over the Jones-Orme Co.

Literature

Constant Groove Speed. Catalog No. 40 describes the method of constant groove speed developed by Recordall Mfg. Co., 2619 Santa Fe Ave., Los Angeles, Cal. The catalog also contains illustrations and descriptions of the various products available from Recordall.

Timers and Relays. Bulletin No. 4071 announces a new and complete series of automatic reset timers and time delay relays manufactured by Paragon Electric Co., 37 W. Van Buren St., Chicago.


PROGRESS REPORT
ACHESON RESEARCH LABORATORIES

Subject: The Coating of Highly Polished Surfaces with "Dag" Colloidal Graphite

Highly polished surfaces cleaned with metallographic powder and water are readily wetted at room temperature by pure water carrying synthetic graphite in colloidal dispersion. Surfaces which have not been cleaned by this means can be successfully treated with colloidal graphite if they are first heated. Typical relationships follow from Fig. 1, which show suspension concentration plotted against minimum wetting temperature.

These findings of practical value to workers in applied electronics show how adherent graphite films may be readily formed on polished glass and metal to insure electrical conductivity, dry lubrication, "gettering" and other special properties. The July "Review of Scientific Instruments" will carry the above data in augmented form. Write for Technical Bulletins 11, 31, 270.

ACHESON COLLOIDS CORPORATION
PORT HURON, MICHIGAN

dag COLLOIDAL PRODUCTS

Resistors. A 10-page catalog contains a performance chart, complete information on insulated, non-insulated and wire-wound resistors, as well as a chart showing resistance values. Speer Resistor Co., St. Marys, Pa.

Groov-Pin Text Book. A 16-page book, nicely bound, is devoted to describing groov-pins and drive-studs of the Groov-Pin Corp., 411 Kerrigan Ave., Union City, N. J.

Airport Radio Equipment. Two bulletins are available from Radio Receptor Co., 251 West 19th St., New York City. The first is Bulletin 5000 which describes Model No. 421 u-h-f airport traffic control transmitter. Bulletin 5001 treats the subject of Series 424 u-h-f receiver.

New Products

Speaker Units

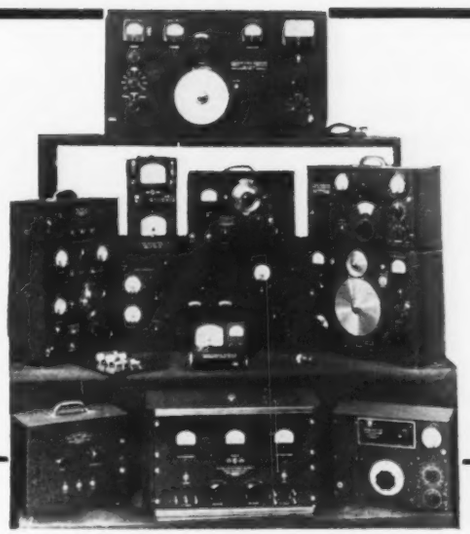
A NEW LINE OF "DYNA-FLUX" compression type permanent magnet speaker units to be used in conjunction with "Morning Glory" reflexed projectors are available from Atlas Sound Corp., 1447 39th St., Brooklyn, N. Y. The units feature non-corrosive diaphragms which are electro-chemically treated, and heat treated for toughness. They are fatigue resistant and protected against crystallization and shattering. The complete unit is protected from adverse weather conditions. The power ratings range from 18 to 20 watts. V. C. impedance 15 ohms.

Oscillator Coils

A NEW SERIES OF "Airwound" Adjustable Link Oscillator and Buffer Coils has recently been announced by Bud Radio Inc. of Cleveland, Ohio. These coils are designed for use in circuits where it is desirable to adjust excitation or antenna loading by varying the link coupling.

Each coil is individually linked, and coupling is varied by pushing the link in or out of the main winding. In view of the fact that each coil has its own link, the coupling adjustment for each band can be left permanently set at the proper value.

All coils in this series fit standard 5-prong sockets and are designed for operation in stages where the input power does not exceed 50 watts. Coils are available for all amateur bands.



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Laminations for Radio Transformers — Tools
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NEW SUPER HI-POWER GENEMOTOR
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150 Watt, Weight 13½ lbs. 8½" Long, 4½" Wide, 5" High

Sets a new high standard for Power Units used on Marine, Police, and Aircraft Radio. The exceptional Hi Efficiency, small size, and light weight are the result of a new type, one piece field ring, and armature design. Grease packed ball bearings require no oiling or attention. Double enamel and silk wire on armature insure trouble-free operation; end dust cover removable. Made in two sizes, 150 and 225 watt output, up to 1000 volts, input 5.5 volt and up.

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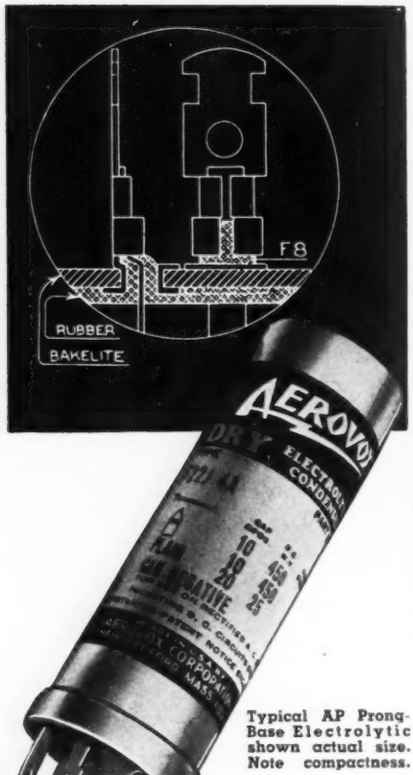


Typical AP Prong-Base Electrolytic shown actual size. Note compactness.

New and Better PRONG-BASE ELECTROLYTICS

- **AEROVOX takes particular pride in presenting its new Series AF electrolytics. Similar in appearance and purpose to conventional prong-base electrolytics, these AF units incorporate several vital improvements, such as:**
- **Square can shoulder instead of usual 30° sloped shoulder. Result, cap or plug rests solidly in place. No danger of shearing cathode tab.**
- **In place of usual two bakelite discs separated by sheet of flat rubber, AP construction utilizes cup-shaped molded soft-rubber disc in which fits bakelite disc. Lugs eyeletted to bakelite disc.**
- **Cup-shaped rubber disc has slotted protrusions or sleeves through which pass anode or positive tabs which, beyond bend inside of sleeves, join with soldering lug. No leakage of electrolyte. A positive, soft-rubber seal.**
- **No danger of bakelite corrosive effects since rubber sleeves prevent bakelite contacting slot walls in bakelite disc.**
- **Positive pin-hole vent instantly responds to excessive gas pressures, yet normally self-closing.**

Write for DATA . . .

- **Complete technical details regarding this AP construction, sent on request; also samples and quotations to responsible parties. Get the facts!**

AEROVOX
CORPORATION
NEW BEDFORD, MASS.
IN CANADA: AEROVOX CANADA Limited Hamilton, Ont.

Resistors. Bulletin 122-M is devoted to a detailed discussion of the electrical and mechanical specifications of the various standard and special non-inductive, wire-wound, accurate resistors available from Shallcross Mfg. Co., Collingdale, Pa.

Weston Bulletins. The following literature is available from Weston Electrical Instrument Corp., Newark, N. J.: Model 787 is described in detail in "Ultra High Frequency Oscillator and Associated Equipment" for television, police, aircraft, utility, and amateur radios; Catalog T-11-B deals with temperature gauges for different uses; "Power Level Indicators", DB meters; "Technical Data on Photoelectric Cells"; Model 776 Oscillator; Model 791 Portable Dry Battery Tester; Model 767 Filatrol Tubechecker; Photoelectric Potentiometer Model 721; Model 639, Type 2, Industrial Analyzer; All metal laboratory thermometer; Multi-range, multi-purpose test instruments for industry, laboratory and school; and "Tools for Better Seeing" which includes illumination meters and foot-candle meters.

Resistors and Rheostats. Catalog No. 40 contains information on resistors and rheostats manufactured by Hardwick-Hindle Inc., Newark, N. J.

Test Instruments. The 1940 Catalog No. 122 of Radio City Products Co., 88 Park Place, New York City, includes descriptive information on 15 test instruments manufactured by them.

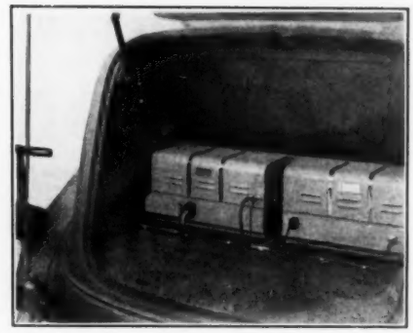
Transformers. Such information as "T" line components; "T" line, broadcast and industrial, and portable broadcast transformers; radio range filters; and "A" line transformers, as well as decibel charts, etc., are included in a bulletin available from Kenyon Transformer Co., 840 Barry St., New York City.

Telephones and Equipment. Various types of voice powered telephones and equipment are included in a catalog issued by United States Instrument Corp., 19 S. Harrison St., East Orange, N. J.

1940 Catalog. A new catalog of technical and scientific books published by Chemical Publishing Co., 146 Lafayette St., New York City, is available from them.

Vibrator Power Supplies. Supplement No. 7 to the 3rd edition of Mallory-Yaxley Radio Service Encyclopedia, Indianapolis, Ind., includes general theory of vibrators, history and design, etc.

Relays. Bulletin No. 250-1940 describes 1.5 watt input—2000 watt output relay No. 25 for medium contact load, low power input, ruggedness, and compactness. It is available from Kurman Electric Co., 241 Lafayette St., New York City.



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TWO-WAY POLICE RADIOTELEPHONE

- ★ 8 AND 20 WATT TRANSMITTERS
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Write for complete technical specifications

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PALO ALTO, CALIFORNIA

Manufacturers of High-Grade Marine and Police Radiotelephone Equipment

THIS new "Locking Acorn Socket" with positive locking contacts and "Iso-Q" insulation, is the last word in sockets. With its new contact design, this socket can be mounted in any position without danger of the tube becoming loose. It is ideal for portable equipment. The silver plated Berryllium contacts are firmly anchored in the base so that they can not shift. Each socket has a copper shield to complete the internal tube shielding.

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Dependable
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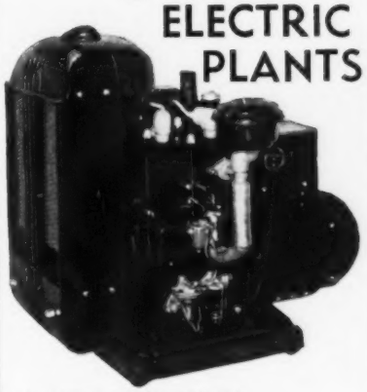

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Supply you with Emergency Current Dur.ng Power Shut Downs.

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. . . because CARRIER has the looks and the QUALITY. Shown above, dynamic No. 702-D, with exclusive CARRIER "Acoustic Equalizer" that insures amazingly wide range; Hepco locking type cable connector; magnetic shielding; sealed; response ±2½ db, 30 to 10,000 cycles; output level —60 db.

Other models, professional in looks and performance, widely preferred by veterans in broadcasting, recording, reinforcing. Truly, any CARRIER model's a mike you'll like!

Send for complete catalog 10-B

CARRIER MICROPHONE CO.
439 So. LaBrea Avenue
Inglewood, Cal.

Receiving Tubes

RAYTHEON PRODUCTION CORP., have added several new tube types to their receiving tube line, as follows:

1D8GT is a 1.4-volt battery type with the bantam construction. This tube has a diode, a triode and pentode to perform the functions of detector, audio amplifier and power output stage.

6AB5/6N5 replaces the type 6AB5 and 6N5. A T-9 bulb is used and the electrical characteristics have been designed to retain the sensitivity of the 6AB5 together with the extended cutoff of the 6N5.

6AL6G is a 6.3 volt type designed for use as an amplifier in television receivers. The characteristics are similar to those of a 6L6G but the plate lead is brought out to a top cap to allow a high momentary peak voltage rating.

7H7 is a high mutual conductance pentode which has been designed to have as wide a cutoff as is consistent with a good ratio of g_m to plate current. This tube has a 2.0 watt cathode in place of the usual 3.0 watt cathode used in other high g_m amplifier tubes and hence may be used in series with other 2.0 watt cathodes. This new type will find application in untuned r-f circuits, wide band, high frequency amplifiers and other equipment where the high g_m characteristics are desirable.

35Z6G is a twin diode rectifier designed for use in voltage doubler circuits in ac-dc receivers. It is characterized by a plate current rating of 110 ma which is somewhat higher than similar ratings for other voltage doublers such as the 25Z6G.

50C6G is a 50 volt power amplifier with characteristics like those of the 6Y6G. The high heater voltage makes this tube very suitable for use in ac-dc receivers.

70L7GT is a dual section tube containing a half wave rectifier and a beam power amplifier.

Communications Receiver

MODEL RME-99, of Radio Mfg. Engineers, Peoria, Ill., is a 12 tube receiver with high frequency tuning. Among its outstanding features are a 6-position variable crystal selectivity control, a voltage regulator tube, wide spaced tuning condenser for stability, calibrated band spread dial for each of the amateur bands from 10 to 80 meters inclusive, use of the high efficiency loktal tubes, and an automatic noise limiter with a manual adjustment for added convenience in operation. The frequency coverage of this unit includes all channels from 540 to 33,000 kc with a nearly uniform sensitivity.

Portable Printer

THE ELPRO PORTABLE PRINTER, sold by the Ozalid Corporation, Johnson City, New York, has been developed for applications where occasional prints are required. It will make positive type re-

A Hallicrafters Radiophone gives dependable service from any boat to every telephone in the world. There is a model exactly fitting your requirements.

50 WATT (Model MT-12). Seagoing range. 10 frequency transmitter. 10 frequency receiver. Both crystal controlled. Separate power supply for 110, 32 or 12 volts. Dimensions 20½ x 19¼ x 12. Bulk head or table mounting.

25 WATT (Model HT-8). Cruising range. 5 frequency transmitter (crystal controlled). 6 frequency receiver. 15 x 18 x 10.

12 WATT (Model HT-11). Local range. 3 frequency transmitter. 2 band receiver (Marine and Broadcast). 13 x 8½ x 9.

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CHICAGO, U. S. A.

USED BY 33 GOVERNMENTS —SOLD IN 89 COUNTRIES

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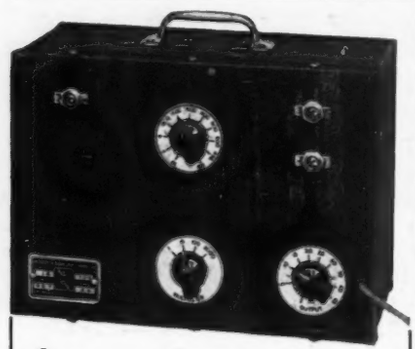
Precision LEVEL INDICATOR

The Type 910 Volume Level Indicator is an audio level indicator designed for service in broadcasting, sound recording, and allied fields. The meter is sensitive, rugged and correctly damped for program monitoring. The meter multiplier is a heavy duty, step type "T" attenuator designed to offer a constant impedance both to the line, and to the meter at all steps of control. The zero adjustment provides corrections of ± 0.5 Db. in 0.1 Db. steps. The input impedance of the 910 is 7500 ohms. The reference level is 1 mw. into 600 ohms.

WRITE FOR TECHNICAL DESCRIPTIVE LITERATURE

THE DAVEN COMPANY

158 SUMMIT STREET · NEWARK, NEW JERSEY



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the Model 14 is tried and proven

* Maximum economy
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* 10 frequencies as selected
* Variable air condenser for each frequency
* Range 100 k. c. thru F-M band

Additional information on this and other Signal Generators on request.

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Acclaimed The Industry's Much Needed Recorder's Aid..

A *Gamble Publication*

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A-M and F-M Receiver

MODEL S-27 RECEIVER AVAILABLE from Hallicrafters, Inc., Chicago, was designed to cover the regular and experimental services utilizing wavelengths down to 2 meters and provides for reception of both a-m and f-m signals. Descriptive literature is available from the manufacturers.

Television Equipment

AMONG NEW DEVELOPMENTS in television by Farnsworth Television & Radio Corp., Fort Wayne, Ind., is the production in commercial form of a complete line of studio and transmitting equipment. Latest additions to the line are dual monitor console control, studio rack equipment, transmitter of 1,000 watts rating and single sideband filter. These units with pick-up cameras and telecine projector constitute the apparatus needed to operate a telecasting station.

Plug-In Electrolytics

PLUG-IN ELECTROLYTICS are now available from Aerovox Corp. of New Bedford, Mass., to designers, manufacturers, servicemen, and operators of radio and electronic equipment. The condensers are changed with the ease and speed of radio tubes or vibrators and permit instant removal without tools or trouble for testing and replacement.

Oscillograph

IMPROVEMENTS AND REFINEMENTS have been worked into the latest Type 208 oscillograph announced by Allen B. Du Mont Labs., Passaic, N. J. The new construction permits short, low-capacity, low-impedance leads between all circuits. The instrument is supplied with an intensifier-type cathode-ray tube utilizing electrostatic focusing and orthogonal electrodynamic deflection. Unusually high-gain amplifiers have been provided for deflection on both horizontal and vertical axes, while a gas-discharge type relaxation oscillator provides a sweep circuit for the delineation of unknown signals as a linear function of time.

Radio Noise Meter

TYPE 312, an instrument for the accurate measurement of radio noise and interference was developed by RCA Mfg. Co., Camden, N. J., as a result of recommendations of a joint committee from the Edison Electrical Institute, the R.M.A., and the N.E.M.A. Built both for service in the field and in the laboratory, its principal uses include measuring the noise levels of transmission lines, electrical apparatus, and field strength of radio signals in comparison with noise levels. When equipped with a directive loop antenna, it indicates the direction of signals and interfering noises.

Plastic Enamel

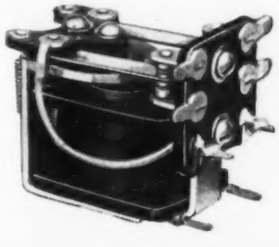
A RECENT DEVELOPMENT by the chemists of Sherwin-Williams Co., of Cleveland, is the new enamel called Kem Bakolescent in the iridescent form, and Kem Plastite in solid colors. This new enamel can be dipped or sprayed on plastic parts and can combine any color of the rainbow with an extraordinarily long-wearing surface. One suggested use is in electrical wiring devices. The new finish makes it possible to coat cheap black plastic materials with beautiful iridescent colors.

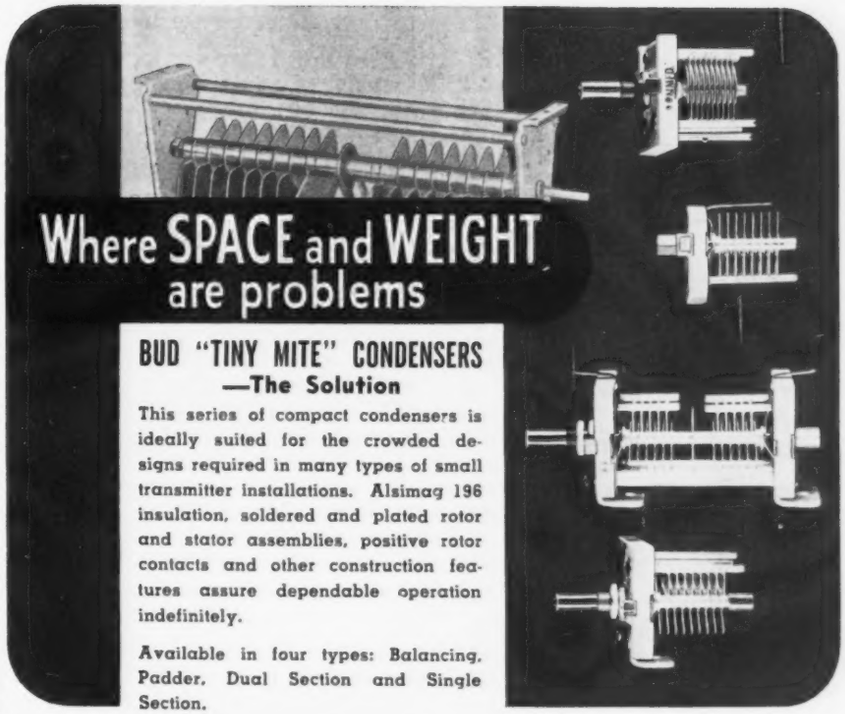
Portable Receiver

LEAR AVIA INC. (Learadio), Roosevelt Field, Mineola, L. I., have introduced the Tri-Powr portable receiver, featuring choice of a-c, d-c or battery operation by merely flipping a switch. It is a portable receiver which can be used indefinitely indoors without the penalty of battery loss. The Tri-Powr can be used in the air or out-of-doors on its own batteries, or on any ordinary electrical outlet without the slightest battery wear. Other features of this receiver are: radio-range plus commercial broadcast reception, phone jack for use on air-craft band, external terminal for connecting aircraft antenna, battery life of 200 hours or more, weight of only 12½ pounds complete.

New Midget Relay

OF PARTICULAR INTEREST where size and cost are important factors is the new midget relay developed by Advance Electric Co., 1260 West 2nd St., Los Angeles, Cal. The relay measures 1½x¾ inches and weighs 2 ounces. Available for a-c and d-c operations; requires 0.10 watts for positive service; and will dissipate 2 watts without danger.





BUD "TINY MITE" CONDENSERS
—The Solution

This series of compact condensers is ideally suited for the crowded designs required in many types of small transmitter installations. Alsimag 196 insulation, soldered and plated rotor and stator assemblies, positive rotor contacts and other construction features assure dependable operation indefinitely.

Available in four types: Balancing, Padder, Dual Section and Single Section.

Inquiries welcomed concerning all types of variable condenser requirements. Complete information regarding the comprehensive BUD line of condensers gladly sent on request.

BUD RADIO, INC.
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The DECADE BOX
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Covers resistance range of 1 ohm to 999,999 ohms, up to 1000 v. max.
★
Each decade dissipates up to 225 watts. Green-ohms (wire-wound cement-coated power resistors) used throughout. Glass-insulated wiring.
★
Six decade switches on sloping front panel.
★
Max. current per decade: No. 1, 5 amp.; No. 2, 1.5 amp.; No. 3, .5 amp.; No. 4, .15 amp.; No. 5, .05 amp.; No. 6, .005 amp.
★
Handsome frosted-gray metal case. Etched black and aluminum panel. Dual input binding posts, for left and right hand duty.
★
Grille at bottom and louvres at side for adequate ventilation. Baffle plate protects switch mechanism from heat.
★
Measures 13" long x 8½" deep x 5¾" high. Weighs 11 lbs.

★ From "The House of Resistors" comes the very thing you laboratory workers and engineers have been waiting for—the Clarostat Power Resistor Decade Box. Handles *real* power. Simplifies and expedites selection of correct resistance values for any circuit or working condition. A handsome instrument truly worthy of a place in every well-equipped laboratory or engineering department. ★ Write for descriptive literature.

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BLILEY CRYSTALS

HOLDERS OVENS

ONLY carefully selected Brazilian Quartz is used in the manufacture of Bliley General Communication Frequency Crystals. As each individual crystal passes through its various processing operations, many optical, mechanical and electrical examinations are applied to insure the highest possible standards of precision and quality.

So that proper characteristics and frequency accuracy can be guaranteed, each crystal is finally checked and calibrated in the holder in which it will operate. Bliley crystal holders and oven mountings are engineered particularly for dependable performance of Bliley Crystals from 20kc. to 30mc. Various types are available to suit frequency control requirements throughout the complete crystal frequency range.

A competent engineering staff is maintained for product research and development. Recommendations and quotations covering quartz crystals for any standard or special applications will gladly be extended without obligation. Write for catalog G-10 describing Bliley General Communication Frequency Crystals.

BLILEY ELECTRIC CO.
UNION STATION BUILDING ERIE, PA.

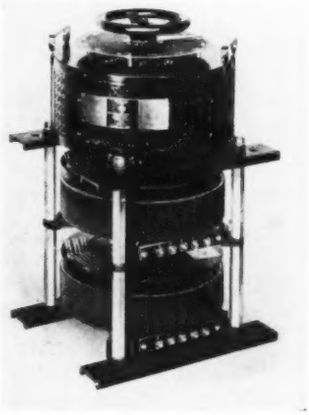
productions in sizes up to 12x18 inches of engineering drawings, maps, letters, reports, and in fact any pencil or ink lines, typewritten or printed matter appearing on one side of a reasonably translucent material. Exposure is made by six specially designed lamps with a total of 800 watts. This equipment operates on 110 volts ac or dc, and is portable. A time release switch allows the operator to regulate exposure automatically.

Variacs For Three-Phase Operation

GENERAL RADIO, (CAMBRIDGE, MASS.,) Type 50 Variacs, 5 kw size, can now be provided in 2- and 3-gang combinations for use on three-phase circuits, and with current equalizing chokes for parallel operation on single-phase circuits.

Both 115- and 230-volt models are available. The 230 volt, 3 gang, unit can be used in the wye connection on 560 volt circuits to obtain continuously variable output voltages from 0 to 560 volts with a maximum output of 30 kva. Because the Variac is an autotransformer, internal power losses are negligible.

General Radio also announces the Type 759-B Sound-Level Meter, an improved model of the older Type 759-A. The new instrument meets the standard specifications for sound-level meters as adopted by the ASA and various engineering societies. It is suitable for use in noise surveys, and for measuring the noise generated by machines and appliances.

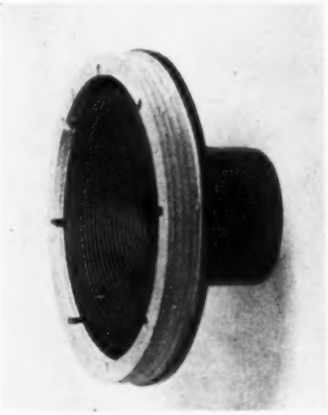


Antenna

RADEX CORP. ANNOUNCES a new shielded loop antenna which can be used in conjunction with any test oscillator or signal generator, to align loop antenna radio receivers. The unit is complete with dummy antenna and shielded generator leads, housed in an attractive chromium plated shield and black crackle finished base. Radex Corp. is now located in new and larger quarters at 1733 N. Milwaukee Ave., Chicago.

Loudspeaker Cone

A NEW TYPE OF "ACCORDION EDGE" loudspeaker, 7 ins. in diameter, has been perfected by RCA Mfg. Co., Camden, N. J. to reproduce low frequencies with good fidelity. The instrument (Model MI-6233) has a frequency response of from 80 to 7,000 cycles. The accordion design permits the cone to move more freely when driven by a permanent magnet speaker mechanism, and increases the lower reproduction range by at least one octave.



Acorn Socket

A NEW SOCKET FOR ACORN tubes which really clamps the tube in place so that it cannot work loose is available from Hammarlund Mfg., Co., 424 West 33 St., New York City.

Contacts are silver plated beryllium, provided with grooves so that the tube snaps into place, permitting the socket to be mounted in any position. The socket has a metal shield which, when used with the pentode type acorn tube, completes the internal shielding of the tube and thus greatly reduces coupling between input and output circuits. The base is made of "Iso-Q", providing exceptionally low losses with improved power factor.

The UHS-900 has an overall base diameter of 1 9/16 inch with 1 3/16 inch mounting centers.

Relay

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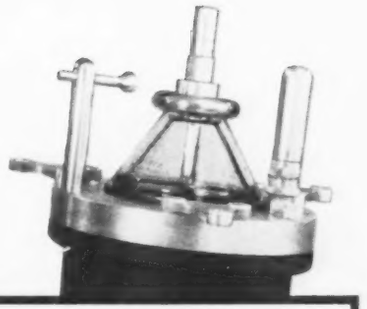
interior of the sound cell with the external air so as to permit equalization of pressure for operation of the ear at reduced pressures. This novel feature is useful for testing aircraft telephone receivers when it is desired to simulate the pressure and density conditions obtaining at high altitudes. The size of the duct is chosen so that its presence does not in any way affect the acoustical performance of the sound cell. A similar duct is provided in the leak for the same purpose. A convenient arrangement for such tests is a bell jar large enough to enclose the artificial ear and receiver under test, provision for introducing the connecting leads into the jar, a small vacuum pump and manometer. Other types of artificial ears employing condenser microphones are not suitable for use at reduced pressures because of the lack of pressure equalization behind the diaphragm in the microphone. It is felt that this feature will greatly extend the usefulness of the artificial ear, especially for investigations connected with receivers used in aircraft.

Telephone Receiver Testing

The acoustical performance of the telephone receiver is measured in terms of the acoustical pressure developed at the ear drum. This pressure is generally expressed in root-mean square bars (1 bar = 1 dyne per square cm).

There are several ways of expressing the efficiency of a telephone receiver, depending upon the definition of "efficiency" which is adopted. Since the receiver is inductive it is necessary, in order to draw the maximum amount of power from a source, to match the inductive reactance by an equal capacitive reactance, as well as to match the resistance to that of the source. This cannot be done when the receiver is to operate over a range of frequencies, hence the power input to the telephone receiver from a resistive source is always limited by the inductance of the receiver. The real power input into the receiver may be determined by measuring the resistive component of the receiver impedance and multiplying by the square of the current. Near the principal resonance of the receiver diaphragm the impedance fluctuates rapidly and the resistance measurement is a diffi-



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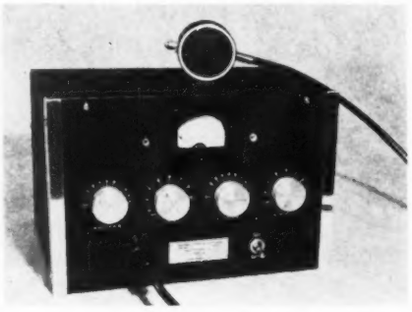

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• • •

Voltage Control

(*Continued from page 21*)

ing to which the current in any branch of a network is found by opening this branch, measuring or calculating the voltage across the break and dividing this voltage by the impedance measured between the break with all impressed voltages shortcircuited. The open circuit voltage is clearly the e we have already calculated, while the total impedance across the break (see Fig. 4) with the applied voltage shorted equals

$$Z_t = 2 \times \frac{R \times R_D}{R + R_D} + Z = R_B + Z$$

where Z_t is the total impedance and R_B the bridge resistance or bridge impedance. The use of the dynamic resistance rather than the actual lamp resistance is justified, since we are interested only in the current changes due to small voltage changes. The voltage actually appearing across the load impedance will then be

$$e_Z = e \times \frac{Z}{Z_t}$$

The circuit is very simple and stable and provides all the advantages of a zero method without the necessity of a standard to which the unknown, varying voltage must usually be compared.

Artificial Ear for Testing Telephone Receivers

(*Continued from page 35*)

manent calibration. In lieu of such calibration an output control is provided at the side of the case so that for most precise work the variation in output with temperature can be compensated for. This compensation may be carried out by using the standard telephone receiver supplied with the equipment. Since the temperature will usually change very slowly standardization will be necessary only at infrequent intervals.

When a telephone receiver is held against the ear in the normal fashion there will seldom be a tight seal between the receiver cap and the external ear. This is specially true in the case of watch-case receivers in head-band mountings. Such leakage acts acoustically like an inertance (acoustic inductance) and tends to resonate with the compliance of the ear volume at low frequencies, thus changing the pressure developed at the drum. It is sometimes desirable to take this into consideration in testing and in the design of the artificial ear the leakage has been incorporated as shown at G (Fig. 2). Removal of the plug H provides a passage to the open air of such proportions as to resonate with the ear volume at a frequency in the neighborhood of 400 cps. *It must be pointed out that the design of this leak is entirely arbitrary, depending to a large extent upon the pressure with which the receiver is held against the ear.* The design chosen, however, represents a good average value. This arbitrariness with regard to the design of the leak should be borne in mind in comparing results obtained with artificial ears of various types. We have found the leak of doubtful value in routine testing and recommend that it be closed as a standard testing condition. It is of value however, in research work as indicating the general effect of an imperfect seal between the ear and the cap of the receiver.

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cult one. The impedance also depends upon the current and must be measured at the specified input level. The sound-pressure developed by the receiver is proportional to the current or to the square root of the power, hence an "efficiency" or "power sensitivity" factor based upon this may be defined as follows:

$$\tau_0 = p/\sqrt{W} \qquad (1)$$

where p is the acoustical pressure developed in the artificial ear and W is the input power. This can be expressed in decibels if desired, using a reference value of 1 bar for the pressure and 1 milliwatt for the power.

$$\tau_0 = 20 \log_{10} (p/\sqrt{W}) \qquad (2)$$

Of fundamental interest regarding telephone performance is the relation between the sound-pressure developed in the artificial ear and frequency since this determines the quality of the reproduced sound and enables us to estimate the frequency distortion produced by the receiver. Such curves are usually taken with constant voltage across the receiver, constant current through the receiver, or with a generator impedance of a certain value. The latter condition simulates the actual circuit conditions more closely and is of practical interest. For example suppose we want to find the frequency characteristic of a certain pair of telephones connected to the plate circuit of a vacuum tube amplifier. We can place in series with the telephones a resistance equal to the output resistance of the tube and apply constant voltage to the series combination. Since the voltage generated by the best oscillator is usually constant over the frequency range it is merely necessary to select the proper output impedance, adding to this an external resistance if necessary to secure the proper total series resistance.

Figure 4 shows a complete frequency response characteristic of a standard Bell hand receiver taken with a constant current of 3 milliamperes. The solid curve was taken with the leak cut out and the dotted curve was taken with leakage. The prominent peak near 1000 cps is due to mechanical resonance of the diaphragm as modified slightly by the acoustical reactions of the ear. A second group of resonances occurs in the vicinity of 3000 cps. One of these is due to the diaphragm vi-

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brating in a higher mode with a single nodal circle. Others are due to acoustical resonance between the inertance of the air in the hole in the ear cap and the compliance of the associated volumes of the diaphragm chamber and to resonance in the ear canal.

Tests on Hearing-Aid Receivers

The Type 505 artificial ear can also be used for measurements on receivers used in hearing aids. For this purpose an adapter is necessary. The average hearing-aid receiver is coupled to the ear by means of an extension which fits into the ear canal. In some cases these extensions are more or less straight; in others special mouldings are made to fit the curvature of the ear canal more accurately. Measurements made on a number of different commercial types indicate that the small ducts in them do not differ much in dimensions and this information has been used in the design of a standard adapter having a duct approximately $\frac{5}{8}$ inch long and 3/32 inch in diameter. This adapter fits into the rubber auricle of the artificial ear and simulates the acoustical condition which exists when the hearing-aid receiver is worn on the ear. Measurements have shown that the curvature of the duct has no effect so the duct can be made straight, as shown, since this is more convenient mechanically.

The procedure in testing hearing-aid receivers is the same as that used for ordinary telephone receivers. Those of the electromagnetic type can be tested at constant current or voltage, while in the case of crystal receivers it is customary to test them at constant voltage. A voltage of the order of 20 will usually be sufficient. Figure 5 shows a frequency-response curve on a commercial hearing-aid receiver tested at a constant voltage of 15.

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